HAND-BOOK

OF THE

ANATOMY AND DISEASES

OF THE

EYE AND EAR

FOR STUDENTS AND PRACTITIONERS

BY

D. B. St. JOHN ROOSA, M.D., LL.D.

Professor of Diseases of the Eye and Ear in the New York Post-Graduate Medical School; formerly President of the New York Academy of Medicine, etc.

AND

A. EDWARD DAVIS, A.M., M.D.

Professor of Diseases of the Eye in the New York Post-Graduate Medical School; Fellow of the New York Academy of Medicine

PHILADELPHIA

F. A. DAVIS COMPANY, Publishers

1904

Philadelphia, Pa., U. S. A.
The Medical Bulletin Printing-house,
1914-16 Cherry Street.

PREFACE.

Although the book herewith presented does not contain a large number of pages, it does exhibit, as the authors believe, the present state of Ophthalmology and Otology in sufficient proportions, even if abbreviated, to make an exact and reliable guide as to the principles of treatment of the diseases of the eye and ear, and to the anatomy of these organs. In the judgment of the writers, the undergraduate and the post-graduate both need manuals in their study of the Eye and Ear, but they need them in such a succinct form that in a very short space of time they can corroborate and amplify what they see in clinics, and thus fasten it in their minds for ready use. As a guide, then, to these two classes of students, who are in the midst of seeing patients in the dispensaries and the clinics, and also as a reference work to the busy practitioner, we hope this little hand-book will be found very useful. The authors have taken great pains to see that not only the well-established views of the nature and treatment of Ophthalmic and Aural disease have been presented, but also those that are on trial, while such as have been abandoned receive scanty or no attention. A very full and complete index has been added to facilitate quick reference.

New York, August, 1904.

CONTENTS.

PART I.

ANATOMY AND DISEASES OF THE EYE.

CHAPTER I.

ANATOMY AND PHYSIOLOGY OF THE EYE.

	PAGE
Physiology of the Eye	1
Anatomy of the Eye	2
Orbits	2
Optic Nerves	4
Eyeball	6
Sclerotic Coat	7
Cornea	9
Uveal Tract	11
Choroid	11
Ciliary Body	12
Ciliary Processes	14
Arteries of the Ciliary Body	14
Iris	15
Retina	17
Crystalline Lens	21
Zonule of Zinn	22
Vitreous Body	23
Aqueous Humor	24
Muscles of the Eyeball	24
Blood-vessels of the Eye	27
Lymphatics of the Eye	29
Nerves of the Eye	30
Appendages of the Eye	31
Eyebrows	31
Eyelids	32
Conjunctiva	33
Eyelashes	34
Lacrymal Apparatus	36

CHAPTER II.

Examination of the Eye.

	PAGE
How to Examine an Eye	40
How to Examine the Conjunctiva	41
Oblique Illumination	43
Intra-ocular Tension	43
Acuteness of Vision	44
Range of Accommodation	45
Determining the Refraction	47
Ophthalmometer	47
Trial Glasses	48
Field of Vision	50
Color-perception	52
Fixation	52
Double Vision	53
Prisms	54
Testing the Power of the Muscles	55
Binocular Vision	58
Ophthalmoscope	59
Therapeutics of the Eye	64
Aseptic Precautions	64
Protective Bandage	65
Eye-shades	65
Protective Spectacles	65
Hermetical Bandage	65
Local Bloodletting	66
Cold Applications	66
Hot Applications	67
Mydriatics	67
Atropin	67
Duboisin	69
Cocain	69
Euphthalmin	69
Myotics	69
Eserin	69
Pilocarpin	70
Irritants and Caustics	71
Powdered Calomel	71
Ointment of Mercury	71
Solution of Tannic Acid	71
Solution of Protargol	71

PAGE

Irritants and Caustics (*Continued*).
- Solution of Argentamin 71
- Solution of Argonin 71
- Solution of Silver Nitrate 71
- Solution of Argyrol 72
- Crystals of Copper 72
- Crystals of Alum 72
- Lotions of Zinc 72
- Lotions of Alum 72
- Lotions of Copper 72

Local Anesthetics 72
- Cocain 72
- Holocain 73
- Eucain 73

Jequirity 73
Exclusion from Light 73
Surgery of the Eye 74
Paracentesis of the Cornea 74
Saemisch's Operation 74
Trephining the Cornea 75
Iridectomy 75
Iridotomy 75
Corelysis 76
Cataract Operations 76
- Linear Extraction 77
- Simple Extraction 77
- Graefe's Modified Extraction 78
- Liebreich's Extraction 79
- Needling Operation 80

Tenotomy for Strabismus 81
Advancement Operations 82
Bowman's Operation 84
Canthoplasty 85
Entropion, Operations for 86
Enucleation 88

CHAPTER III.

Diseases of the Eye.

Orbit 92
- Injuries 92
- Emphysema 93

	PAGE
Orbit (*Continued*).	
Hemorrhages	93
Abscess	93
Periostitis	94
Caries	95
Aneurism	95
Exophthalmic Goiter	96
Conjunctiva	96
Foreign Bodies	96
Injuries	97
Ecchymosis	97
Emphysema	98
Conjunctivitis	98
Catarrhal	98
Purulent	100
Gonorrheal	101
In Newborn	101
Diphtheritic	102
Croupous	103
Granular	104
Phlyctenular	106
Pterygium	107
Xerophthalmia	108
Symblepharon	109
Ankyloblepharon	109
Tumors of the Conjunctiva	109
Cornea	110
Injuries	110
Foreign Bodies	110
Herpes	111
Burns	112
Keratitis	112
Vascular	113
Phlyctenular	114
Interstitial	115
Suppurative	116
Ulcerative	117
Abscess	118
Pannus	119
Opacities	120
Tattooing	122
Staphyloma	122
Conical	124
Hydrophthalmia	125

PAGE

Cornea (*Continued*).
Fistula 125
Sclera 126
Episcleritis 126
Staphyloma 126
Wounds 126
Iris 127
Injuries 127
Foreign Bodies 127
Iritis, Simple 127
Syphilitic 128
Rheumatic 128
Gonorrheal 129
Tuberculous 130
Mydriasis 131
Myosis 131
Hippus 132
Iridodonesis 132
Cysts 132
Malignant Growths 132
Congenital Defects 133
Choroid 133
Rupture 133
Choroiditis 133
Disseminated 134
Suppurative 134
Serous 135
Sclerotico-posterior 136
Tumors 137
Tuberculosis 137
Deposits of Bone in 137
Coloboma 137
Ciliary Body 138
Cyclitis 138
Retina 139
Hyperemia 139
Hyperesthesia 139
Anesthesia 140
Retinitis 140
Apoplectic 141
Albuminuric 141
Pigmentosa 142
Detachment 145
Tumors 145
Crystalline Lens 145

Crystalline Lens (*Continued*). PAGE

Cataract 145

Traumatic 146

Capsular 147

Senile 147

Secondary 150

Dislocation of Lens 150

Vitreous Humor 151

Foreign Bodies 151

Hemorrhages 152

Opacities 152

Hyalitis 153

Cysticercus 154

Persistent Hyaloid Artery 151

Anterior Chamber 151

Hypopyon 151

Hypemia 151

Foreign Bodies 151

Optic Nerve 155

Optic Neuritis 155

Atrophy 155

Opaque Nerve-fibers 156

Amaurosis 157

Amblyopia 157

Glaucoma 158

Acute 159

Chronic 160

Secondary 160

Sympathetic Ophthalmia 162

Ocular Muscles 167

Strabismus 167

Convergent 169

Divergent 169

Paralytic 170

Nystagmus 173

Insufficiency of Internal Recti 173

Eyelids 175

Blepharitis 175

Hordeolum 176

Chalazion 177

Deformities 178

Trichiasis 178

Distichiasis 178

Entropion 178

Ectropion 178

	PAGE
Eyelids (*Continued*).	
Ptosis	179
Paralysis of the Orbicular Muscle	180
Blepharospasm	180
Injuries	181
Nictitation	181
Ecchymosis	181
Epicanthus	181
Coloboma	181
Ephidrosis	182
Chromidrosis	182
Xanthelasma	182
Lacrymal Apparatus	182
Lacrymal Catarrh	182
Dacryocystitis	183
Blennorrhea of Sac	184
Fistula of Sac	184
Diseases of Lacrymal Gland	184

CHAPTER IV.

ANOMALIES OF REFRACTION AND ACCOMMODATION.

Refraction	186
Accommodation	186
Emmetropia	186
Ametropia	186
Asthenopia	187
Myopia	187
Hypermetropia	189
Astigmatism	191
Presbyopia	193
Anisometropia	194
Aphakia	194
Paralysis of Accommodation	194
Spasm of Accommodation	195
Retinoscopy	195
Simulated Blindness	196
Photopsia	197
Micropsia	197
Macropsia	197
Metamorphopsia	197
Color-blindness	198

PART II.

Anatomy and Diseases of the Ear.

CHAPTER V.

Anatomy and Physiology of the Ear.

	PAGE
Sense of Hearing	199
External Ear	200
Auricle	200
Muscles	201
Middle Ear	204
Drumhead	204
Cavity of Tympanum	207
Bones	209
Mastoid Cells	212
Eustachian Tube	213
Internal Ear	215
Bony Cavities	215
Vestibule	215
Semicircular Canals	217
Cochlea	217
Membranous Labyrinth	220
Utricle	220
Canals	221
Saccule	222
Terminal Auditory Apparatus	224
Auditory Nerve	226
Internal Auditory Canal	228

CHAPTER VI.

Examination and Diagnosis of Aural Disease.

Tests of Hearing	229
Eustachian Catheter	233
Politzer's Method	233
Valsalva's Method	235

CHAPTER VII.

Methods of Treating Diseases of the Ear.

	PAGE
Irrigation	237
Leeching	238
Blisters	238
Poultices	238
Paracentesis of Drum Membrane	239
Excision of Ossicles	242
Aids to Hearing	212

CHAPTER VIII.

Diseases of the Ear.

Auricle	245
Injuries	245
Eczema	245
Erysipelas	245
Tumors	246
Malformations	247
Chondritis	247
Abscess	248
External Auditory Canal	248
Foreign Bodies	248
Hardened Wax	249
Diffuse Inflammation	250
Furuncle	251
Eczema	252
Fungi	252
Polypi	253
Ulcers	254
Exostoses	254
Cysts	254
Tumors	254
Middle Ear	254
Injuries	254
Myringitis	255
Fractures	256
Catarrh, Acute	256

Middle Ear, Catarrh (*Continued*). PAGE
Subacute 258
Chronic 259
Chronic Proliferous Inflammation 264
Suppuration, Acute 265
Chronic 266
Consequences of Chronic Suppuration 269
Malignant Growths 270
Cysts 270
Tubercular Nodules 270
Exostoses 270
Diseases of the Mastoid 271
Periostitis 271
Wilde's Incision 272
Abscess 272
Operations on Mastoid 272
Schwartze's Operation 272
Trephining Operation 275
Cerebral Abscess 276
Stacke's Operation 277

CHAPTER IX.

INTERNAL EAR.

Nervous Deafness 282
Deaf-mutism 284
Ear-cough 284
Cophosis 285
Hyperacusis 285
Double Hearing 285
Presbykousis 285
Otalgia 286

INDEX 287

PART I.

ANATOMY AND DISEASES OF THE EYE.

ANATOMY AND DISEASES OF THE EYE.

CHAPTER I.

THE ANATOMY AND PHYSIOLOGY OF THE EYE.

PHYSIOLOGY.

THE visual apparatus consists of the eyeballs and their accessory parts for collecting luminous impressions and the optic nerves for conveying them to the brain. Each eyeball forms a hollow globe, filled with a clear, gelatinous substance—the vitreous. It is blackened on its interior surface, having a system of convex lenses in front for forming images of external objects, and a special nervous membrane—THE RETINA—behind for receiving them. The whole is like a camera obscura. The light, passing through the cornea, aqueous humor, lens, and vitreous humor, is focused upon the retina (which appreciates both intensity and color), and inverted images of objects are formed there. These impressions are conveyed to the brain by the optic nerves, and thence results the sensation which we call VISION. The manner in which we gain our visual perception of an object, single and erect, from its two inverted retinal images cannot be satisfactorily explained. The amount of light admitted to the eye is regulated by the reflex movements of the iris—the pupil contracting in a bright light and dilating in

a feeble one. The eye possesses the faculty of accommodation—that is, of adjusting itself for vision at different distances; so that the focus of the rays of light is kept in the retina alike when we look at a far-off landscape or read a book. Only a small part of an object can be seen *distinctly* at any one time, the surrounding parts being more or less blurred; on the other hand, the eye is so rotated by its muscles as to command a very extensive field. The two eyes act in perfect harmony, and the images, being symmetrically disposed on the two retinæ, are combined into a single impression. The two retinal images are slightly different (each eye seeing its corresponding half of the object most distinctly), and from their union result our ideas of solidity—that is, we get an idea of the depth or thickness of an object, as well as its length and breadth. Our ideas of *distance* are derived from the muscular efforts required to see distinctly and from experience.

Anatomy of the Eyeball, the Orbit, and the Eyelids.

The Orbits.

These are bony cavities in which the eyeballs are securely contained. They are shaped like four-sided pyramids, the bases pointing forward and outward, the apices backward and inward. They are about 1 $^3/_5$ inches deep. Their axes are inclined to each other at an angle of 42 degrees. Each orbit is formed from seven bones; frontal, sphenoid, ethmoid, superior maxillary, palate, malar, and lacrymal, the three former being common to both orbits. The ROOF is formed by the frontal and sphenoid, is very thin, and separates the orbit from the cranial cavity and frontal sinus; there is a fossa

for the lacrymal gland at the outer, anterior angle, and a depression *(fovea trochlearis)* for the pulley of the superior oblique muscle at the inner angle. The FLOOR is formed by the superior maxillary, malar, and palate bones; near the center is the *infra-orbital groove,* running from behind forward, converted into a canal which opens on the face $^1/_6$ inch below the orbital margin, and transmits the infra-orbital vessels and nerve. The INNER WALL is formed by the superior maxillary, ethmoid, sphenoid, and lacrymal bones; it is very thin—from $^1/_{128}$ to $^1/_{64}$ inch; anteriorly has the *lacrymal groove* (for the lacrymal sac), bounded in front and behind by *anterior* and *posterior lacrymal crests.* The OUTER WALL is formed by the malar and sphenoid bones. It is from $^1/_{13}$ to $^1/_{12}$ inch thick, and presents *zygomatico-temporal* and *zygomatico-facial* (or *malar*) *foramina* for the nerves of the same name. In the suture between the inner wall and the roof are the *anterior* and *posterior ethmoidal* foramina for the ethmoidal vessels and nasal nerves. Between the roof and the outer wall posteriorly is the *sphenoidal fissure* for the third, fourth, ophthalmic division of the fifth, and the sixth nerves, and ophthalmic vein. Between the floor and the outer wall posteriorly is the *spheno-maxillary fissure* for the intra-orbital vessels and nerve and ascending branches from the spheno-palatine ganglion. The BASE is the facial opening of the orbit, 1 $^3/_5$ inches wide, 1 $^1/_3$ inches high; it has a strong, bony edge, pierced above, about 1 inch from the median line of the skull, by the *supra-orbital notch,* or *foramen,* for the supra-orbital vessels and nerve; the bases are $^3/_4$ inch apart. The APEX is formed by the optic foramen and canal; the canal is funnel-shaped, runs between the two roots of the lesser wing of the sphenoid, backward, upward, and

inward to the middle fossa of the skull—$^1/_3$ inch long, $^1/_4$ inch caliber; and it transmits the optic nerve and ophthalmic artery. The orbits are lined by periosteum (or *periorbita)*, which is continuous at the fissures and sutures with that of the facial bones and with the dura mater; it forms a tendinous ring about the optic foramen, giving origin to ocular muscles. On the periosteum is a layer of connective tissue and fat, forming a cushion for the eyeball; the connective tissue is thickened to form sheaths for the muscles, vessels, and nerves, and fasciæ for connecting different parts within the orbit with each other and with the periosteum. Such fasciæ connect the cartilages of the lids with the edge of the orbit and with the capsule of the globes, and surround the muscles of the eye with a funnel-like sheath. One, starting from the optic foramen, surrounds the optic nerve, then spreads over the eyeball, *tunica vaginalis bulbi,* and is lost anteriorly on the sclerotic; it is pierced by the tendons of the muscles, with which it is connected; the posterior part is loosely attached, allowing the eyeball to rotate in it, and is called *Bonnet's capsule,* while the part anterior to the passage of the tendons is called *Tenon's capsule.* Rudimentary organic muscles are found in the orbit—*external, internal,* and *inferior orbital,* which are supposed to strengthen the union of the lids with the orbit; the inferior, the largest, $^1/_{25}$ inch thick, covers the infra-orbital fissure.

The Optic Nerves.

These nerves have their origin in the *thalami* and *corpora quadrigemina,* receiving filaments from the *corpora geniculata, tuber cinereum, lamina cinerea, anterior perforated space, gray substance of the brain,* and the *posterior*

columns of the spinal cord. The fibers run forward, as *optic tracts,* beneath the thalami and across crura to the front of the infundibulum, where they unite to form the *optic chiasm* (Gr. χιασμα, the letter χ), in which they decussate. The chiasm rests on the olivary process of the sphenoid bone. From the inner end of each tract fibers cross to the nerve of the other side, and supply the inner half of the opposite retina. About two-fifths run directly, without crossing, to the outer half of the retina of the same side. The vessels of the tracts and chiasm are from the pia mater and the brain. The *optic nerves* proper start from the lateral portions of the chiasm, run divergent to the optic foramina, thence through the orbits to enter the eyeballs $^4/_{25}$ inch within and $^1/_{25}$ inch below the posterior pole. The length of the nerve from the chiasm to the foramen is $^2/_5$ inch; from the latter to the eyeball, about $1\,^1/_8$ inches. The optic nerves consist of bundles of medullated fibers, forming about half their bulk, separated from each other by connective-tissue fibers and vessels. They are surrounded by a sheath of pia mater (its neurilemma), while the orbital portion is surrounded, in addition, by two other membranes (arachnoid and dura mater). The sheaths are joined together by loose connective tissue and are supplied by twigs from the ciliary and muscular arteries. The space between them is called *intervaginal, subvaginal,* or *subdural space.* At the entrance into the sclerotic the optic nerve becomes thinner and the fibers lose their medullary sheaths; tendonlike processes from the neurilemma are more abundant, joined by fibers from the sheath of the central artery and from the sclera, forming the *lamina cribrosa,* which covers the scleral opening like a sieve, with the convexity backward; sometimes it contains

pigment. Beyond this, the nerve-fibers are slightly elevated above the inner surface of the sclera, forming the *optic papilla* or *optic disc*—a roundish prominence about $^1/_{17}$ inch in diameter. The nerve-fibers radiate from the disc into the retina in all directions. The *central artery of the retina*, or *arteria centralis retinæ*, enters the nerve from $^3/_5$ to $^4/_5$ inch behind the eyeball, and runs forward in the center of the nerve to the papilla, where it branches into the retina. It is inclosed in a sheath of its own. Nutrient capillaries of the nerve from the anterior cerebral, central artery, and vessels of the neurilemma anastomose in the papilla with branches from the short ciliary arteries. A *central vein* accompanies the artery, inclosed in a separate sheath. It leaves the nerve a little nearer the eyeball and empties into the cavernous sinus, anastomosing with the ophthalmic and facial veins. The *lymphatics* are numerous in the nerve and sheaths. The spaces between the sheaths are regarded as lymph-spaces with which the lymphatics of the nerve and the posterior parts of the eye connect. This space connects with the arachnoidal lymph-space of the brain.

The Eyeball, or Bulbus Oculi.

The eyeball is spheroidal in form with the segment of a smaller sphere projecting from its anterior surface. The eye measures about 1 inch in all its diameters. The *anterior pole* is the geometric center of the cornea. The *posterior pole* is the geometric center of the back part of the globe. The *optic axis* is the imaginary straight line from pole to pole. The *visual line* is an imaginary straight line drawn through the nodal point from the macula lutea to an object; it usually cuts the cornea a little above the optic axis, and at

an angle of from 3 to 7 degrees to the inner side of it. The *nodal* point is the center of curvature of the refracting surfaces. It lies a little in front of the posterior surface of the lens. The *equatorial plane* is the imaginary plane through the center of the eye perpendicular to its axis, dividing the globe into anterior and posterior *hemispheres.* The *equator* is the line where the equatorial plane cuts the surface of the globe. *Meridional planes* are the imaginary planes coinciding with the optic axis. The *meridians* are lines where the meridional planes cut the surface. The eyeball is composed of three tunics; *(a) sclerotic* and *cornea, (b) uveal tract* or *tunica vasculosa,* comprising *choroid, ciliary body,* and *iris,* and *(c) retina;* and three humors: *(a) aqueous, (b) crystalline lens,* and *(c) vitreous.*

THE SCLEROTIC COAT, OR THE SCLERA.

(Gr. σκληρός, hard.)

The sclera is a dense, white, fibrous membrane which, together with the cornea, forms a complete outer tunic for the eyeball. The cornea forms the anterior one-sixth and the sclera the posterior five-sixths. The sclera forms a firm capsule for the globe, helping to maintain the proper shape and to protect the parts within. It gives attachment to the ocular muscles. The sclera is thickest posteriorly ($^1/_{20}$ inch), where it is joined by the optic sheaths; and thinnest at the anterior border ($^1/_{60}$ inch). The inner layers continue directly across the optic nerve entrance, but are perforated by many fine openings, forming the *lamina cribrosa.* Through these openings pass the bundles of optic-nerve fibers, denuded of their medullary sheaths. The sclera termi-

nates anteriorly in the cornea, its elements being transformed into corneal tissue. The union is by beveled surfaces, the sclera overlapping the cornea anteriorly and to a slighter extent posteriorly; slight circular depression, or *sulcus,* around the corneal margin. The outer surface is somewhat rough, connected by loose connective tissue to the sheath of the globe, and anteriorly to the conjunctiva by shorter filaments —*subconjunctival tissue.* The inner surface is closely connected to the choroid and ciliary body by a layer of connective tissue, *lamina fusca,* containing pigment cells. The sclera is composed chiefly of connective tissue with elastic fibers, pigment cells, and cells corresponding to corneal corpuscles intermixed. The connective-tissue bundles have a longitudinal and circular course, interlacing to form a dense meshwork; and form a circular ring at the anterior edge around the cornea. The pigment cells are most abundant at the inner surface. At the anterior edge near the inner surface is a circular space surrounding the cornea, *Schlemm's canal,* lined by endothelium and inclosing a venous plexus. It receives veins from the sclera and from the ciliary plexus; communicates with the anterior chamber and anterior ciliary veins. It is regarded by some as a venous reservoir for the ciliary muscle. The sclera is pierced around the optic-nerve entrance by the long and short ciliary arteries, posterior ciliary veins, and short ciliary nerves; in the region of the equator by *venæ vorticosæ;* around the corneal border by anterior ciliary arteries and veins. The passages of long and anterior ciliary arteries and vorticose veins are very oblique. The sclerotic receives blood from the ciliary system; the vessels are not numerous and form a coarse network. Around the optic-nerve entrance in the posterior *vascular zone* (zone

of Zinn or Haller), formed from twigs of the short ciliary arteries, which sends branches to the optic nerve, anastomosing with those of the central artery, thus forming the only connection between the ciliary and retinal systems. On the anterior surface, around the cornea, is the anterior *vascular zone,* formed from the episcleral or subconjunctival branches of the anterior ciliary vessels. It is about $^1/_6$ inch wide; and anastomoses with the conjunctival vessels. The existence of nerves in the sclera is doubtful.

THE CORNEA.

(Lat. *cornu*, a horn.)

The cornea is a transparent, highly polished membrane, forming the anterior one-sixth of the external tunic, and projecting from the sclerotic like a segment of a smaller sphere from a larger one. It is ellipsoidal in shape, with the radius of curvature a little less than 8 millimeters. It is slightly more convex in the vertical than in the horizontal meridian. The transverse diameter is longer than the vertical, owing to overlapping of the sclerotic above and below. The thickness at the center is $^1/_{28}$ inch; at the periphery, $^1/_{22}$ inch. The refractive index, 1.342. There are five layers from without inward:—

1. *Epithelial layer,* continuous from the conjunctival epithelium.
2. *Anterior elastic lamina*—Bowman's or Reichert's membrane.
3. *Substantia propria,* or true corneal tissue.
4. *Posterior elastic lamina,* or Descemet's membrane.
5. *Endothelial layer.*

The layer of conjunctival epithelium is $^3/_{2500}$ inch thick; and consists of two or three layers of transparent nucleated cells, the superficial ones flattened, the deeper ones oblong and placed perpendicularly to the surface; it passes over at the edge *(limbus)* of the cornea into the epithelium of the ocular conjunctiva. Bowman's membrane, from $^1/_{5000}$ to $^1/_{2500}$ inch thick, is a firm, elastic, homogeneous basement membrane and is quite resistant to chemical agents. The *true corneal tissue* is about $^1/_{25}$ inch thick. It consists of fine, highly refractive connective-tissue fibrillæ united into bundles, and these again into lamellæ whose general direction is parallel to the surface. The space between fibrils, bundles, and lamellæ is filled by a semifluid, cementlike substance; in this is a system of anastomosing spaces and canals containing serous fluid, and a network of corneal corpuscles and wandering cells (Engelmann). The corneal corpuscles are flat or fusiform nucleated cells, with granular protoplasm, sending out anastomosing processes in all directions. *Descemet's membrane* is $^1/_{2500}$ inch thick at the margin, $^1/_{3500}$ inch thick in the center. It is an elastic, structureless inner basement membrane, said by some to have lamellar formation. It is continuous at the margin with the *ligamentum pectinatum* of the iris. The *endothelial layer* consists of a single layer of flattened polygonal, nucleated cells, which line the posterior surface of Descemet's membrane. The cornea has no blood-vessels except at the periphery, where there is a zone, from $^1/_{25}$ to $^1/_{18}$ inch wide, of capillary loops formed from the episcleral branches of the ciliary arteries, which anastomose with conjunctival branches, the veinlets emptying into the anterior ciliary veins. *Nerves:* from twenty to forty-five twigs are derived chiefly from the long

and short ciliary, and a few from conjunctival branches of the lacrymal and infratrochlear nerves; the former enter through the sclera, the latter pass in from the limbus. Just after entering the cornea the nerve-branches lose their medullary sheaths and form a very intricate network beneath Bowman's membrane and in the anterior epithelial layer; also a smaller plexus near Descemet's membrane. The fibers run forward and end among the superficial epithelial cells in a manner not yet settled.

THE UVEAL TRACT.

(Lat. *uva*, grapes.)

CHOROID (Gr. χόριον, skin, and εἶδος, like) extends from the edge of the optic-nerve entrance to an imaginary boundary, *ora serrata*, a little in front of the equator. It lies between the sclerotic and the retina, to which it is most closely attached around the nerve and at the *ora serrata*. The thickness is from $^1/_{300}$ to $^1/_{150}$ inch. Its layers from without inward are:—

1. *Lamina fusca* (Lat. *fuscus*, dark), or *suprachoroidea*.
2. *Tunica vasculosa.*
3. *Membrana choriocapillaris*, or *Ruyschiana*.
4. *Lamina elastica*—vitreous or limiting membrane.

The inner pigment layer, often described with the choroid, belongs to the retina. The *lamina fusca* is composed of connective tissue containing free nuclei and nucleated, branching pigment cells, brown and black; it surrounds the vessels and nerves passing forward to the iris and ciliary body; a space is left—*suprachoroidal* or *perichoroidal* space—between the choroid and the sclera, lined by endothelium, communicating with Tenon's space through the canals around

the *venæ vorticosæ;* considered as lymph-space. The *tunica vasculosa* consists of the larger arteries and veins, which run a tortuous course and pass gradually into deeper capillary layer. The *membrana choriocapillaris* is a fine capillary network covering the inner surface from the optic nerve to the *ora serrata.* The meshes are finest posteriorly. *Limiting membrane* is about $^1/_{5000}$ inch thick. It is a structureless, hyaline membrane covering the inner surface of the capillary layer. The elements of the choroid are bound together by *stroma*—a network of fibers in whose meshes are variously formed pigment cells and lymphoid corpuscles. Smooth, unstriped *muscular fibers* have been found along the vessels, and scattered through the stroma. Pigment in the choroid is less abundant in light eyes. The *arteries:* short posterior ciliary, which become wholly lost in the capillary layer, not passing beyond the ora serrata. These are recurrent branches from long posterior and anterior ciliary. The *veins,* after very numerous ramifications and anastomoses, unite into larger *venæ vorticosæ,* four to six in number, which pass out through the sclera near the equator. They carry off most of the blood from the uveal tract, only a small part escaping by the anterior ciliary veins. The *nerves* are from the third, fifth, and sympathetic through the long and short ciliary, which pierce the sclerotic around the optic-nerve entrance, and form a fine network in which many ganglionic cells are found.

The CILIARY BODY is that portion of the uveal tract between the ora serrata and the iris forming the middle zone of the uveal tract. It consists of the ciliary muscle, covered by the choroidal stroma, and the ciliary processes. The *ciliary muscle,* or *tensor choroideæ,* is composed of a layer

of unstriped muscular fibers, situated in the anterior and outer part of the ciliary body, separated from the sclerotic by the lamina fusca. In a vertical section it has prismatic shape, base forward, from $^3/_{25}$ to $^4/_{25}$ inch thick at base; the external fibers have meridional course, forming the thickest part of the muscle. The middle fibers diverge and radiate toward the inner side, where they form a circular plexus; at the anterior internal angle they are separate, circular bundles, the *annular muscle of Müller;* meridional and radiate fibers arise by a tendinous ring from the inner side of Schlemm's canal at the junction of the sclera and the cornea; they are connected with the ciliary processes and choroid. The nerve-supply is from the third nerve. The ciliary muscle is probably the chief agent in *accommodation.* The meridional fibers draw the choroidal border forward and the circular fibers draw parts inward, thus relaxing the zonula and allowing the lens to become more convex from its own elasticity. During accommodation, the pupil contracts, the free margin of the iris moves forward, the lens is pushed forward, its anterior surface becoming more convex (Helmholtz). Although the text-books state that the muscular element of the ciliary body was discovered independently by Burke and Bowman in 1846, William Clay Wallace, an oculist of New York City, discovered and described it in 1836.

Tscherning (Paris, 1893) promulgated a theory of accommodation differing from the usually accepted one of Helmholtz. Tscherning says: "By the contraction of the ciliary muscle the anterior part of the deep layer exercises a traction on the zonula, which on one side gives the shape to the crystalline lens which it assumes during accommodation, and on the other side gives it a tendency to move backward.

At the same time the posterior extremity of the muscle, by its traction on the choroid, produces an increase of tension in the vitreous humor which keeps the crystalline lens in place."

Tscherning thinks that his theory of accommodation is supported by clinical observations—the diminution of tension in the anterior chamber during accommodation, the palliative effects of eserin in glaucoma, and so forth.

The CILIARY PROCESSES.—These are from seventy to eighty parallel, meridional folds of the choroid, rising gradually from behind forward, and forming a plaited zone —looking like a ruffle—on the inner surface of the ciliary muscle; it is about $^1/_{16}$ inch long. They possess the same structure as the choroid, without its capillary layer. They are covered internally by a continuation of the retinal pigment; they are joined by external (anterior) margins to the ciliary muscle, the internal (posterior) margins and bases being free and resting in corresponding depressions on the surface of the zone. There is a space about $^1/_{50}$ inch wide left between the bases of the processes and border of the lens.

The Arteries of the Ciliary Body.—The long, posterior ciliary arteries run forward, one on the outer and one on the inner side of the globe. They penetrate the ciliary muscle and, with branches from the anterior ciliary, form the *circulus arteriosus major* at its anterior border. A smaller circle is formed in the same way farther back; the capillary plexus of the muscle is derived from these circles and also directly from the ciliary arteries. The *arteries of the ciliary processes* are derived from the *circulus major.* The *veins* of the muscle and processes empty chiefly into the venæ vorticosæ, some joining with the anterior ciliary.

THE IRIS.

(Gr. ἶρις, a rainbow.)

This forms the anterior zone of the uveal tract. It arises from the anterior portion of the ciliary body, forming a circular diaphragm with a central opening called the *pupil.* The pupil is situated a little to the nasal side of the center. The mean diameter is from $^2/_{25}$ to $^6/_{25}$ inch. It is fringed with pigment from the pigment layer on the posterior surface of the iris. It varies in size from muscular action; when dilated to the maximum, the edge floats free in the aqueous humor; when contracted, it rests on the anterior capsule of the lens. The iris is from $^7/_{50}$ to $^9/_{50}$ inch wide; from $^1/_{125}$ to $^2/_{125}$ inch thick. It is attached at the ciliary margin by its suspensory ligament, *ligamentum pectinatum iridis,* formed by radiating fibers which run from the margin of the anterior surface and bend forward at the edge to join the fibrous network around the border of Descemet's membrane. The anterior surface is uneven, and divided by a jagged line into two zones: (1) *pupillary,* $^1/_{25}$ inch wide, and marked by fine, radiating folds; (2) *ciliary,* $^3/_{25}$ inch wide (allowing $^4/_{25}$ inch for pupil), and marked by from five to seven concentric folds. It is covered by a layer of irregular cells continuous with those of Descemet's membrane. The posterior surface is covered by a layer of pigment cells, *tapetum* or *uvea* (Lat. *tapete,* carpet), continuous with the pigment layer of the ciliary processes; marked by from five to seven shallow radiating folds. The *stroma* is loose, composed of a connective-tissue network, continuous with that of the choroid and ciliary body, containing muscular fibers, vessels, nerves, and round and stellate cells. In dark eyes the cells

are strongly pigmented and often seen as superficial, irregular spots. In light eyes the cells are nonpigmented and the color is due to an *interference phenomenon.* The layer of circular muscular fibers is about $^3/_{500}$ inch thick and $^1/_{25}$ inch wide, around the border of the pupil, forming *sphincter pupillæ.* Radiating muscular fibers in the iris have been described by some authors, but their existence is doubtful. The dilation of the pupil may be brought about by the limiting membrane, which is elastic. The *arteries* are from the *circulus major iridis* in the ciliary muscle. The walls are very thick. The vessels run toward the pupil, giving out a branching network, and near the pupillary margin they form the *circulus arteriosus iridis minor;* which ends in loops that pass into the veins at the edge of the pupil. In albinos the color of the blood shows through the walls of the vessels. The *veins* nearly all pass back to the plexus of ciliary processes and so into the venæ vorticosæ; some of them pass through the veins of the ciliary muscle into the anterior ciliary veins. The *nerves* are from the third, fifth, and sympathetic, through the long and the short ciliary. They form a fine plexus in the stroma. The sphincter muscle is supplied by the third, the dilator by the sympathetic, while the sensitive fibers are from the fifth. The movements of the iris are *reflex* from the action of light on the retina, and *accommodative* in unison with ciliary muscle and internal recti muscles. The movements of the two irides are consensual. The intersection of the iris, ciliary body, cornea, and the sclera is called the *iritic angle.*

THE RETINA.

(Lat. *rete*, a net.)

The retina forms the inner tunic of the eye. It lies between the choroid and the vitreous body and extends from the optic nerve to the ora serrata. It is of a delicate grayish color, quite transparent. It is about $^1/_{75}$ inch thick at the papilla, growing thinner toward the ora serrata, where it is about $^1/_{200}$ inch thick. It is composed of nervous elements—somewhat like the neuroglia in the brain—and modified connective tissue. The layers from the vitreous outward are:—

1. *Membrana limitans interna.*
2. *Optic-nerve fibers.*
3. *Ganglion cells.*
4. *Internal molecular.*
5. *Internal granules.*
6. *External molecular* or *intergranular.*
7. *External granules.*
8. *Limitans externa.*
9. *Rods and cones,* or *Jacob's membrane.*
10. *Pigment layer.*

1. The *hyaline membrane* is modified connective tissue formed by the expanded inner extremities of the radiating fibers of Müller, $^1/_{12\,500}$ inch thick, and lies in close contact with the hyaloid membrane of the vitreous.

2. The optic-nerve fibers are transparent and homogeneous. They are like those of the brain, radiating from the optic papilla in all directions. They are devoid of medullary sheaths, and are not sensitive to light. The posterior half of the layer is $^1/_{125}$ inch thick. It grows thinner as it goes forward and disappears at the ora serrata.

3. *Ganglion Cells.*—This layer is composed of a single layer of ganglion cells with nuclei and nucleoli, having branching processes in variable number, some of which appear identical with nerve-fibers; the layer is about $^3/_{5000}$ inch thick.

4. *Internal Molecular.*—This is formed of the finest nerve-fibers and connective-tissue network, with fine granules of unknown nature. The layer is about $^1/_{1200}$ inch thick.

5. *Internal Granular.*—Small, round cells with large nuclei connected with radial connective-tissue fibers and nerve-fibers form the layer. The processes from the cells pass through the molecular layer and unite with ganglion cells (?). The layer is about $^1/_{1300}$ inch thick.

6. *External Molecular.*—Is formed of connective tissue, nuclei, granular substance, and nerve-fibrillæ. The layer is about $^1/_{2000}$ inch thick.

7. *External Granular.*—This layer is composed of nucleated cells ellipsoidal in shape, transversely striated, with the long axis perpendicular to the plane of the retina. They form nucleated enlargements of internal rod and cone fibers which run through this layer to reach No. 6, in which they arise (?). The inner part of the layer is devoid of granules. The layer is from $^1/_{1000}$ to $^1/_{500}$ inch thick.

8. *Limitans Externa.*—This is a membranous expansion of the radial connective-tissue fibers. It is not continuous, but is perforated by numerous foramina.

9. *The Perceptive Layer.*—The rods and cones are packed together like palisades, forming an external nervous layer. They are probably the terminals of the optic-nerve fibers. They have a striated appearance from fine lines of connective tissue surrounding them; they are divided into

external and internal segments connected together by a sheath and filled with highly refractive molecular matter; delicate fibers, *rod and cone fibers,* run inward from the rods and cones and appear to arise by club-shaped and finely fibrillated expansions in the external molecular layer; external granules are connected with them. The existence of axial fibers in the rods and cones is doubtful. The rods are cylindrical in shape, $^1/_{500}$ inch long and $^1/_{8300}$ inch thick. The cones are flask-shaped, about $^1/_{800}$ inch long and $^1/_{5000}$ inch thick. The layer is about $^1/_{500}$ inch thick.

10. *Pigment Layer.*—A single stratum of hexagonal cells forms this layer. They are pressed closely together, containing brownish-black pigment and held together by homogeneous connective tissue. They send processes inward which surround the rods and cones—*pigment sheaths.* They are closely connected externally to the choroid. Pigment is almost absent in albinos. There is a small quantity in blondes, and most exists in negroes.

The Retinal Purple, Visual Purple, or Seh-purpur.—This is a purplish coloring of the external layer of the retina, which was specially studied and described by Professor Boll, of Rome, and Professor Kühne, of Heidelberg. It has been found in most animals examined. It is destroyed by the action of daylight, and restored again by darkness. It disappears after death. Its restoration during life is thought to be a function of the epithelial layer lying between the retina and the choroid. Some animals seem destitute of it, and it is not proven to exist in the *fovea centralis* of man; hence it cannot be said to be essential to the perception of light. It is thought to contribute to the reddish color seen on looking into the eye with the ophthalmoscope.

The *supporting connective tissue* consists of radial fibers stretched between the limitans externa and interna and spongy tissue, forming networks and sheaths for the nervous elements.

The Yellow Spot of Soemmering (1804), *or Macula Lutea* (Latin equivalent).—This is the most sensitive part of the retina and is the center of direct vision. It is situated about from $^1/_{12}$ to $^1/_{10}$ inch to the outer side of the center of the optic disc. It is horizontally oval and of variable size—from $^1/_{25}$ to $^1/_{17}$ inch diameter. It has a central fossa-like excavation—the *fovea centralis,* from $^1/_{125}$ to $^2/_{125}$ inch in diameter. The nerve-elements of the retina are crowded together in the macula at the expense of the connective tissue. The ganglion cells and external granular layer are thicker. The rods are replaced by closely packed cones, which converge toward the center. The rod and cone fibers run diagonally or parallel to the retinal surface; the nerve-fiber layer is interrupted, fibers passing around the macula in curves; the pigment cells are increased; they are longer than broad and darker in color.

The *ora serrata* (Latin for serrated boundary) is the anterior limit of the retina and is situated just posterior to the ciliary body; there is a gradual disappearance of the nervous elements here, leaving only connective tissue and pigment layers, which are continued forward over the ciliary body as the *pars ciliaris retinæ.*

The *blood-vessels of the retina* are from the central vessels of the optic nerve, which divide in the papilla or just behind it. They run chiefly vertically, generally two arteries and two veins in each direction; they divide in an arborescent manner and terminate in a capillary network,

but do not pass beyond ora serrata. The main branches lie in the nerve-fiber layer, the capillaries passing as far as the internal granules. There are only capillaries at the macula and no vessels whatever in the fovea. The retinal blood-vessels terminate in free endings, no anastomoses taking place. There can be no compensatory circulation when one of the branches becomes plugged by an embolus. Vessels said to be surrounded with lymphatics connect with those of the optic nerve.

THE CRYSTALLINE LENS.

The crystalline lens is a biconvex, transparent, elastic body, resting in the hyaloid fossa of the vitreous immediately behind the pupil, inclosed in a capsule and held in place by its suspensory ligament. Its anterior surface is about $^1/_7$ inch from the anterior surface of the cornea. The extreme anterior and posterior portions of the lens are called its *poles*, anterior and posterior, while the straight line joining the poles is the axis of the lens. This lies a little to the temporal side of the center of the cornea. The lens is more convex on the posterior surface than on the anterior. The radius of curvature of the former is about $^6/_{25}$ inch; of the latter, about $^2/_5$ inch. The curvature is slightly greater in the horizontal than in the vertical meridian. The average diameter of the lens is $^9/_{25}$ inch; its axis, about $^4/_{25}$ inch in length; its weight, 4 $^1/_2$ to 5 grains; and its average index of refraction, 1.4371. It contains 60 per cent. of water, 35 per cent. of soluble and 2 $^1/_2$ per cent. of insoluble albuminous matter, 2 per cent. of fat, with a trace of cholesterin. The *capsule* is a transparent, elastic, homogeneous membrane surrounding the lens, and is di-

vided into anterior and posterior portions: It is thickest anteriorly ($^1/_{2000}$ inch), thinner at the margin ($^1/_{5000}$ inch), and thinnest at the posterior pole. On the posterior surface of the anterior capsule is a layer of flat, polygonal cells with round nuclei (formerly considered epithelial), which gradually elongate toward the border of the lens, into true nucleated lens-fibers. The body of the lens is composed of flattened hexagonal fibers with dentated lateral edges, by which they are joined together more firmly than by their flattened surfaces, thus giving the idea of *layers* when they are torn apart. Each fiber curves around the edge of the lens, lying in both halves of the same layer; the greater part do not reach the pole, but join corresponding ones at an acute angle, forming *seams* which run out from the pole like rays of a star, and extend through the whole substance of the lens and thus divide it into sections. The center of the lens is unstratified, denser, and is called the *nucleus*, the surrounding part being the *cortex*. There is a cement-like substance between the fibers: *Liquor Morgagni*, which results from deliquescence of the cortical layers and is wholly due to *postmortem* change (?). The lens has no vessels or nerves; it receives nutriment by imbibition from the uveal tract, vitreous, and aqueous. In the fetus it is covered by a vascular sac from the hyaloid artery, which also closes the pupil—*membrana capsulo-pupillaris*. The lens grows by deposition of new fibers; the cell layer located on the posterior surface of the anterior capsule is considered as the matrix.

Suspensory Ligament, Zonula Ciliaris, or Zonula Zinnii (Zinn, Göttingen, 1755).—This begins just behind the ora serrata by fine filaments, which run longitudinally forward

intimately blended with the retina, tapetum, and hyaloid membrane of the ciliary processes, some passing into the vitreous. In the ciliary region these fibers divide into two layers, the anterior going to the anterior, and the posterior to the posterior capsule of the lens, while the intermediate fibers cross, those rising behind going to the front surface of the capsule, those rising in front going to the posterior surface of the capsule. Between these two folds and the border of the lens is a triangular space—the *canal of Petit.* It is closed during life by the folds' falling together.

THE VITREOUS HUMOR, HYALOID BODY, OR CORPUS VITREUM.

(Lat. *vitreum*, glass.)

The vitreous body fills the interior of the eyeball behind the lens. It is a structureless, gelatinous substance containing nuclei and cells (chiefly in the peripheral parts) and connective-tissue filaments. The cells are round, oval, stellate, nucleated, and finely granular. It is surrounded by a delicate hyaloid membrane. There is a concavity, or cup, in the front part of the vitreous for the crystalline lens to rest in. The hyaloid membrane which surrounds the vitreous is absent in this cup, or lenticular fossa, uniting directly with the posterior capsule of the lens at this point.

The *canal of Cloquet*, or *hyaloid canal*, is $^1/_{25}$ inch in diameter, runs through the center from the papilla to the lens, and contains the hyaloid artery in fetal life, of which a rudiment sometimes persists. The vitreous receives nutriment from the retina and the uveal tract, and has no vessels or nerves. The refractive index is 1.336.

THE AQUEOUS HUMOR.

This is a clear, slightly viscid, serous fluid filling the anterior and posterior chambers; its weight is from $3\,^1/_2$ to 5 grains; specific gravity, 1.0053. It is composed of water (96.687 parts), albumin (0.1223 part), salts, and extractive matter. The refractive index is 1.3366.

The *anterior chamber* is the space between the anterior surface of the iris and lens and the posterior surface of the cornea.

The *posterior chamber* is the space between the anterior surface of the lens, zone, and ciliary body behind, and the posterior surface of the iris in front. While the pupil is dilated and the edge does not rest on the lens, the two chambers communicate.

THE MUSCLES OF THE EYEBALL.

The eye is moved by six muscles, *four recti* and *two oblique.* The center of motion lies on the optic axis 1.77 millimeters (about $^1/_{14}$ inch) behind its center. The rotary power is greater inward and downward than upward and outward. The muscles of both eyes act in harmony and the movements are either *associated* (visual lines being parallel) or *accommodative* (visual lines convergent), the ciliary muscle and sphincter of the pupil participating). When all the muscles are at rest the visual lines converge toward a point from 8 to 12 inches in front of the eyes, the angle between them being called the *muscular mesoropter.*

The *muscle plane* is the plane passing through the center of motion and the line passing from the middle of the origin to the middle of the insertion of the muscle.

The *axis of rotation* is perpendicular to the muscle plane at the turning point. The *base line* is the line connecting the centers of motion. The *median plane* is the plane through the vertical axis of the head and the center of the base line.

The Visual Plane.—This is the plane through the base line and the visual lines.

The Vertical Meridian.—This is drawn perpendicular to the equator when the eye is in primary position. The *primary position* is that in which the visual lines are horizontal and parallel to the meridian plane, the head being erect. All other positions are called *secondary.*

The *four recti* muscles arise from a tendinous ring around the optic foramen, run forward divergently, strike the sheath of the eyeball just behind the equator, and pierce it just before their insertion into the anterior part of the sclera; the tendons are flat, and the lines of insertions are convex anteriorly. The muscles are surrounded by sheaths from the orbital connective tissue, which unite with Tenon's capsule. This connection keeps the muscles against the globe, and prevents too great retraction of the tendons after division.

The Superior Rectus.—The origin is at the upper edge of the optic foramen. The insertion, on the sclera about $^1/_3$ inch from the edge of the cornea. The inner edge is nearer the cornea than the outer. It moves the eye upward and inward and inclines the vertical meridian inward.

The Inferior Rectus.—The origin is at the lower edge of the optic foramen. Insertion, on the sclera about $^2/_7$ inch from the cornea, a little to the nasal side of the center. It moves the eye downward and inward and inclines the vertical meridian outward.

The External Rectus.—The origin is at the external edge of the optic foramen, the ligament of Zinn, and the edge of the sphenoidal fissure. Insertion, on the sclera about $^1/_3$ inch from the cornea. It moves the eye outward.

The Internal Rectus.—The origin is at the internal edge of the optic foramen and ligament of Zinn. The insertion, on the sclera about $^1/_4$ inch from the cornea. It moves the eye inward. It is the strongest of the ocular muscles.

The Superior Oblique.—The origin is from $^1/_{25}$ to $^2/_{25}$ inch anterior to the inner edge of the optic foramen. It passes forward to the upper and inner angle of the orbit through a tendinous pulley, thence outward and backward, beneath the superior rectus to the upper, outer and posterior quadrant of the eyeball, where it pierces the ocular capsule and has a fan-shaped insertion into the sclera about $^3/_5$ inch from the cornea. It moves the front of the eye downward and outward, inclining the vertical meridian inward. The *pulley* (trochlea) of the superior oblique is a tendino-cartilaginous ring attached to the depression at the anterior, inner angle of the orbital plate of the frontal bone.

The Inferior Oblique.—The origin is at the anterior, inner angles of the orbital part of the superior maxillary bone, just external to the lacrymal sac. It passes outward, downward, and backward beneath the inferior rectus, then upward and backward between the external rectus and the globe, and, piercing the ocular sheath, is inserted into the sclerotic close to the superior oblique, about $^2/_3$ inch from the cornea. It moves the front of the eye upward and outward, inclining the vertical meridian outward.

MOVEMENT.	MUSCLE.
Upward	Superior rectus and inferior oblique.
Downward	Inferior rectus and superior oblique.
Inward	Internal rectus.
Outward	External rectus.
Upward and inward	Superior and internal recti and inferior oblique.
Upward and outward	Superior and external recti and inferior oblique.
Downward and inward	Inferior and internal recti and superior oblique.
Downward and outward	Inferior and external recti and superior oblique.

THE NERVE-SUPPLY OF THE MUSCLES.

The third (*oculomotorius*) nerve supplies the superior, inferior, and internal recti and inferior oblique.

The fourth (trochlear) nerve supplies the superior oblique.

The sixth (abducens) nerve supplies the external rectus.

ARTERIES AND VEINS OF THE MUSCLES.

The arteries of the muscles come from the ophthalmic.
The veins empty into the ophthalmic and facial veins.

THE BLOOD-VESSELS OF THE EYE.

THE ARTERIES.—These are derived chiefly from the ophthalmic, which arises from the internal carotid at the anterior clinoid process. It is about $^1/_{12}$ inch in caliber. It enters the orbit below and external to the optic nerve, then crosses above the nerve, between it and the superior rectus

muscle, to the inner wall, and runs forward to the inner angle. The branches from this artery are: *Lacrymal, supra-orbital, anterior* and *posterior ethmoidal, anterior ciliary, long* and *short posterior ciliary, muscular, palpebral, centralis retinæ* (terminal branches), *frontal,* and *nasal.* The infra-orbital (from the internal maxillary of the external carotid) sends branches to the inferior rectus and inferior oblique muscles and to the lacrymal gland. The anterior cerebral sends nutrient capillaries to the optic nerve, and branches from the ciliary and the muscular arteries of the ophthalmic pierce its sheaths and help supply the nerve. In the eyeball itself are two systems: (1) the *retinal,* derived from the centralis retinæ vessels, supplies the retina; and (2) the *choroidal,* or *ciliary,* from the ciliary vessels, which supplies the uveal tract, sclera, margin of the cornea, and part of the ocular conjunctiva. The *short ciliary* vessels, arising from the ophthalmic or one of its branches, consist of from four to six small twigs which divide into about twenty and perforate the sclerotic around the optic nerve. The *long ciliary,* having the same origin as the short, consist of two branches which perforate the sclerotic a little farther forward—one on the outer and one on the inner side. The *anterior ciliary,* arising from the muscular branches, pass through the tendons of the straight muscles and perforates the sclerotic near the corneal margin. The only connection between the two above systems is by small twigs around the optic-nerve entrance.

Anastomosis.—With the deep temporal and transverse facial by the malar branches, and the middle meningeal by the posterior branch from the lacrymal. With the anterior temporal and the angular by the supra-orbital. With the

infra-orbital and the angular by the nasal. With the spheno-palatine by the ethmoidal.

THE VEINS.—The smaller branches empty into two main trunks, *superior* and *inferior ophthalmic,* which run along the roof and floor of the orbit to the cavernous sinus. They have free anastomosis with the facial in front. The blood can thus escape from the orbit in either direction. The short posterior ciliary veins are very small and receive blood only from the sclera. There are no veins corresponding to the long ciliary arteries.

THE LYMPHATICS.

Lymph formed in the eyeball anterior to the ciliary body passes out through the anterior chamber and canal of Schlemm into the anterior ciliary veins.

There are lymph-spaces in the meshes of the trabecular tissue forming the *iritic angle,* called the *spaces of Fontana.* They lie nearer to the anterior chamber than the canal of Schlemm, connect with both, and also with the lymph-channels of the cornea and the sclera. The lymph formed in the posterior parts escapes through channels near the venæ vorticosæ and through the optic nerve. The spaces between the choroid and the sclera *(suprachoroidal* or *perichoroidal),* between the globe and the capsule (space of Tenon), and between the sheaths of the optic nerve (supravaginal and subvaginal) are regarded as lymph-spaces. However, the greatest part of the lymph formed in the eye passes out through Schlemm's canal. When this canal is stopped it usually causes hardness of the eyeball—*i.e.,* glaucoma.

The Nerves of the Eye.

(*a*) Special sense—optic. (*b*) Motor—third, fourth, sixth, filaments from the fifth, and the sympathetic. (*c*) Sensory—ophthalmic division of the fifth. (*d*) Sympathetic branches.

Optic Nerve (see description on page 4).

Third (motor oculi) supplies the superior, the inferior, the internal recti, and the inferior oblique muscles; also the levator palpebræ, the ciliary, and sphincter of the iris. It sends a branch to the ciliary ganglion and receives sympathetic filaments from the cavernous plexus.

Fourth (trochlear patheticus) supplies the superior oblique. It receives sympathetic filaments from the carotid plexus. Sometimes it sends a branch to help form the lacrymal nerve and many times a recurrent branch to the meninges.

Sixth (abducens) supplies the external rectus. It receives filaments from the carotid and cavernous plexuses, from Meckel's ganglion, and from the ophthalmic.

The Ophthalmic Division of the Fifth.—It is joined by sympathetic filaments from the cavernous plexus. Gives off: 1. *Lacrymal,* which supplies the lacrymal gland, the *conjunctiva,* skin of the upper lid, anastomosing with branches from the superior maxillary and facial. 2. *Frontal: (a)* supratrochlear to the corrugator supercilii, joining with the infratrochlear; (*b*) supra-orbital to upper lid, corrugator, and orbicularis, joining with the facial. 3. Nasal or naso-ciliaris: *(a)* ganglionic to the ciliary ganglion; *(b)* long ciliary, two or three, joining the short ciliary and going to the ciliary muscle and iris; (*c*) infratrochlear to the orbicu-

laris, lids, conjunctiva, lacrymal sac, and caruncle, joining the branch from the supratrochlear.

The Sympathetic Branches.—These arise from the medulla, cilio-spinal region, and cavernous and carotid plexuses. They join the third, fourth, fifth, and sixth nerves, and send filaments to the dilator muscle of the iris, to the organic muscles of the orbit and lids, to the ciliary ganglion, and to the walls of vessels.

The Ophthalmic, Lenticular, or Ciliary Ganglion.—It lies in the back part of the orbit between the optic nerve and the external rectus. It is of a reddish color; $^1/_{12}$ inch in diameter. It receives a root from the cavernous plexus of the sympathetic, a long root from the nasal of the ophthalmic, and a short root from the third. It gives off short ciliary branches two or three in number, which subdivide into about twenty, pierce the sclera about $^1/_6$ inch from the optic nerve, and go to the ciliary muscle, iris, choroid, and cornea; also some fine branches to the sheath of the optic nerve.

The Ascending Branches, Spheno-palatine, or Meckel's Ganglion.—These enter the orbit by the spheno-maxillary fissure, and go to the optic and sixth nerve and the ophthalmic ganglion.

The Appendages of the Eye.

The Eyebrows, or Supercilia.—These are arched elevations of skin above the orbit covered with a row of short hairs. They serve to protect the eye, and they influence slightly the amount of light admitted. The *corrugator supercilii muscle* arises at the inner end of the superciliary ridge, and is inserted into the under surface of the *orbicu-*

laris, blending with the *occipito-frontalis.* It is supplied by the facial and ophthalmic division of the fifth nerve, and draws the brow downward and inward.

THE EYELIDS, OR PALPEBRÆ.—These are two movable, protecting folds placed before the eyes, closing the entrance to the orbit. The upper lid is about $^4/_5$ inch, lower about $^1/_2$ inch, high, measured on the inner surface. The space between the free margins is called the *palpebral fissure.* The outer angle of this fissure is called the *external canthus;* the inner angle, *internal canthus* (Gr. κανθός, angle of the eye). The small space between the lids and globe at the inner angle is called the *lacus lachrymalis* (Latin for lacrymal lake). On the edge of each lid about $^1/_5$ inch from the inner canthus is a small elevation, *lacrymal papilla,* containing a minute orifice or *punctum* (Latin for small hole), the beginning of a lacrymal canal, or *canaliculus.* The lids are composed of skin externally, mucous membrane internally, and, between these, areolar tissue, muscle, cartilage, ligaments, glands, vessels, and nerves. The skin is continuous at the edge of the lid with the conjunctiva; is thin and lax, and contains a few fine hairs. The subcutaneous areolar tissue is very loose and contains sweat-glands and hair-follicles. The *tarsal cartilages* are formed of dense, fibrous tissue, not true cartilage; the lower one is elliptical, the upper crescentic and larger; the orbital margins are thinned and passed into fasciæ (palpebral or tarsal ligaments), which connect the cartilages to the edge of the orbit; the free or ciliary margins are thicker and straight. The ligament is thickened to connect the outer angle of the cartilages to the malar bone, and is called the external palpebral or canthal ligament. Connection at the

inner canthus is made by the *tendo oculi* or *palpebrarum*, which is about $^1/_6$ inch long, lying just beneath the skin; it is attached to the nasal process at the superior maxillary bone in front of the lacrymal groove; passes horizontally across the upper part of the lacrymal sac, sending an aponeurosis back to the crest of the lacrymal bone; then divides into two branches, one going to the inner angle of each cartilage. The *Meibomian glands* (Meibomius, seventeenth century) are a variety of cutaneous sebaceous glands imbedded in the cartilages—from thirty to thirty-five in the upper lid, twenty to thirty in the lower lid; each consists of a blind tube into which open secondary follicles, *acini*. These tubes lie parallel and open in a row on the inner lip of the free border of the lid. They furnish sebaceous secretion.

THE CONJUNCTIVA (Lat. *conjungere*, to join together.—This is the mucous membrane lining the lids, reflected thence upon the front of the sclerotic, passing as epithelium over the front of the cornea, forming its anterior layer, the epithelium becoming transparent. At the edge of the cornea it is called *limbus conjunctivæ*. It is continuous with the integument, with the mucous lining of the Meibomian glands, canaliculi, lacrymal sac, and the nasal duct, and extends through the lacrymal ducts into the lacrymal gland. Where it is reflected upon the eyeball—*fornix* (Latin for arch)—it forms the *superior* and *inferior palpebral*, or *retrotarsal, folds;* it also forms a crescentic fold at the inner canthus,—*semilunar fold*, or *semilunaris*,—which is regarded as a rudiment of the third eyelid, or *membrana nictitans*, in birds. The palpebral conjunctiva has a pale-salmon color, with well-defined vessels here and there. It consists of a connective-

tissue basis covered by round, cylindrical, and flat epithelium; the surface is traversed in all directions by furrows, and presents papillæ, papilliform elevations, and orifices of follicular glands. The retrotarsal folds also present conglomerate glands called *accessory lacrymal glands,* and papillæ are here more prominent. The ocular conjunctiva is thin and loosely attached to the globe. It contains a few papillæ and no glands. It is covered by epithelium, which extends over the cornea, becoming transparent as it does so. The *blood-vessels* of the conjunctiva are chiefly from the palpebral and lacrymal arteries. They form a thick network, indirectly connected through the episcleral vessels around the corneal margin with the ciliary system. The *lymphatics* are numerous. They form a close network around the edge of the cornea. The *nerves* are from the fifth pair. They enter at the inner and outer angles of the eye, and form a thick plexus from which nonmedullated fibers ramify beneath the epithelium and end free—some apparently by a club-shaped expansion.

THE EYELASHES, OR CILIA.—They are rows of short, thick hairs on the free margins of the lids, those of the upper lid curving upward, those of the lower downward; their follicles lie in connective tissue upon the cartilages, while sebaceous glands connected with the follicles lubricate the cilia.

MUSCLES.—*Orbicularis Palpebrarum.*—This arises from the internal angular process of the frontal, the nasal process of the superior maxillary in front of the lacrymal groove and the anterior surface and borders of the tendo oculi. The fibers surround the lids and orbits, spreading over the temple and the cheek. The palpebral portion, arising from

the tendo oculi, covers the lids between the subcutaneous areolar tissue and the cartilage; the fibers unite by a cellular *raphé* at the outer angle, some passing into the external canthal ligament and malar bone. The orbicularis is the sphincter of the lids, the palpebral portion having involuntary action. It is supplied by the facial, supra-orbital, and the superior maxillary nerves.

Tensor tarsi, or *Horner's muscle* (Horner, Philadelphia, nineteenth century), is the part of the orbicularis lying behind the *tendo oculi.* It arises from the upper third of the lacrymal crest, passes across the lacrymal sac, and divides into two slips, one of which inserts into each cartilage near the punctum, some fibers surrounding the canaliculi and some running along the edge of the lid to the outer angle. This muscle draws the lid inward and presses the puncta against the globe. It is supplied by the facial nerve.

Levator palpebræ superioris arises from the upper edge of the optic foramen. It runs along the roof of the orbit, and is inserted into the fascia of the upper lid around the upper edge of the cartilage. It raises the lid, and is supplied by the third nerve. Organic muscular fibers, *superior* and *inferior palpebral muscles,* exist in both lids between the conjunctiva and the cartilage. They are supposed to assist in the exact closure of the lids upon the globe. They are supplied by the sympathetic nerves.

THE ARTERIES OF THE LIDS.—They are the principal branches from the ophthalmic; they run along the anterior surfaces of the cartilages near the free edges of the lids, forming the *superior* and *inferior tarsal arches;* from these arches vessels run to the skin, muscles, cartilages, and conjunctiva; free anastomosis takes place with the angular, an-

terior temporal, lacrymal, and transverse facial. The *veins* empty into the temporal and the facial. The *lymphatics* empty into the facial and the submaxillary glands.

Nerves.—The trifacial supplies the skin and the conjunctiva; the facial, third, and sympathetic supply the muscles.

THE CARUNCULA LACRYMALIS (Lat. *caruncula,* a little piece of flesh).—This is a small, red body lying on the semilunar fold in the inner canthus. It consists of from thirteen to fifteen hair-follicles and sebaceous glands, with connective tissue and fat, covered by mucous membrane, and has a few fine hairs on the surface. It is attached to Tenon's capsule and the rectus internus muscle by tendinous fibers, which fact explains the sinking of the caruncle after division of the muscle.

THE LACRYMAL APPARATUS.

This consists of a secreting portion—the *lacrymal gland* and *accessory conjunctival glands,* and a conducting portion—*canaliculi, sac,* and *nasal duct.*

THE LACRYMAL GLAND.—This is composed of: 1. *Upper portion,* of the shape of an almond, lying in a fossa at the outer angle of the roof of the orbit. It is attached to the bone by the tarso-orbital fascia, its under surface resting upon the eyeball. The longest diameter is transverse, about $^3/_5$ inch; weight, 11 grains. 2. *Lower portion,* consisting of a group of small glands arranged in a row just above the fornix conjunctivæ. There are seven to twelve very minute ducts. They open in a row at the outer third of the upper reflection of the conjunctiva. The vessels and nerves enter the gland at the posterior border. The secretion of the gland *(tears)* consists of water, salt,

and albumin; this fluid is spread over the anterior surface of the globe, which it lubricates when winking. The excess of tears collects in the *lacus*, and is forced into the canaliculi by the orbicularis and Horner's muscles, or it flows over the cheek. Under ordinary circumstances the tears evaporate, scarcely any passing into the nose; and they come chiefly from the conjunctiva, so that extirpation of the lacrymal gland does not materially affect the moisture of the globe.

THE CANALICULI (Latin for little channels).—These are two mucous canals from $^1/_4$ to $^1/_3$ inch long and about $^1/_{25}$ inch in diameter, lined by pavement epithelium and enveloped by fibers of Horner's muscle. They begin at the puncta, and run nearly horizontally, and open by common or separate orifices into the outer wall of the lacrymal sac behind the palpebral ligament.

THE LACRYMAL SAC.—This lies in the upper end of the lacrymal canal between the border of the lacrymal bone and the nasal process of the superior maxillary. It is of oval shape, flattened antero-posteriorly, about $^1/_2$ inch long and $^1/_6$ inch wide. The larger part lies below the level of the lower, inner side of the orbit. The upper part *(fundus)* is crossed by the tarsal ligament, extending about $^1/_8$ inch above it. The transition from the sac to the duct is sometimes direct, sometimes interrupted by folds of mucous membrane.

THE NASAL DUCT.—This runs in a bony lacrymal canal, downward, backward, and outward. The curve varies in different subjects. It is $^3/_5$ to $^4/_5$ inch long, about $^1/_{15}$ inch in diameter. It generally opens in the inferior meatus of the nose, just below the attachment of the in-

ferior turbinated bone, sometimes lower. The shape of the opening varies with the situation. It is lined with thick mucous membrane covered with pavement and ciliated epithelium; which is inclosed by a very vascular network of connective tissue and elastic fibers; and, external to this, a tendinous sheath, strengthened above by offshoots from the posterior surface of the palpebral ligament and sheath of Horner's muscle.

The Arteries and Nerves of the Lacrymal Apparatus.—These are small twigs from the neighboring trunks. The gland receives the *lacrymal artery* from the ophthalmic, and also a branch from the infra-orbital, while this sac and duct are supplied by the nasal and palpebral branches from the ophthalmic. The *lacrymal nerve* from the fifth supplies the gland. It also receives branches from the sympathetic. The sac and duct are supplied by the fifth, seventh, and the sympathetic.

Senile Changes.

Senile changes are observed in most of the tissues of the eye. The *sclera* presents calcareous deposits, and a loss of elasticity which favors an onset of glaucoma. The *cornea* becomes smaller and thinner and loses its tone; the elastic laminæ become brittle and present warty elevations at their margins. After the age of 50 (rarely before) *arcus senilis* (Latin for senile bow) may appear, as a result of fatty degeneration. It begins on the upper and lower margins in the form of two superficial, grayish, crescentic opacities with the inner borders indistinct and the outer well defined, leaving a rim of clear cornea on the outer side. These crescentic opacities gradually extend deeper into the

tissue, the ends join, forming a complete circle. The appearance of the arcus senilis is sometimes delayed until advanced age. The *choroid* undergoes atrophy, becomes rigid and brittle, and presents fatty degeneration and calcareous deposits. The vessels become atheromatous, and the capillary layer may be partially destroyed. The membrana limitans is thickened. Analogous changes occur in the ciliary muscle and processes. In the *retina,* sclerosis of the nerve elements and connective tissue occurs, giving a white, dotted appearance; the pigment is bleached and atrophied, causing uneven color; the vessels become atheromatous. The *lens* increases in density, loses elasticity, and becomes flatter. The nucleus assumes an amber color, and molecular opacities appear around it. Changes in the lens-fibers cause radiating opacities; hyaline substance is deposited on the posterior surface of the anterior capsule.

The *zonula* becomes weakened, favoring dislocation of the lens.

CHAPTER II.

THE EXAMINATION OF THE EYE.

As a general rule every external part of the eye should be carefully examined no matter what the symptoms. The outer surface of the lids is easily seen. A glass of about 12 diopters may be used to examine their edges as to position, cleanliness, state of the hair-follicles, and curvature of the lashes. Observe whether the lacrymal puncta are in proper position, and whether any catarrhal secretion can be forced out of them by firm pressure with the finger over the lacrymal sac. The inner surface of the lower lid is easily exposed by pulling the skin of the lid downward with the tip of one finger, while the patient rolls the eye upward. *To evert the upper lid,* have the patient direct his eye—not his head—downward; then the surgeon grasps the central eyelashes between the thumb and finger of the left hand, and pulls the lid a little downward and away from the globe; he then places the tip of the thumb of the right hand upon the skin of the lid, well back from its edge, *so as to be beyond the upper limit of the tarsal cartilage;* then presses a little downward with the thumb of the right hand, and turns the edge of the lid upward by means of the lashes held with the left hand. The thumb of the right hand should then be removed, and the lid held in its everted position by the left hand while it is examined or while applications are being made to it. After a little practice it will be found easy to evert the upper lid in this way. Sometimes it will be found easier to turn it over a probe or pencil than over

the thumb. In small children, where the lids are swollen and congested by crying or other causes, simply separating them with the thumb and finger of one hand will often cause their inner surfaces to be well exposed.

The examination of a child's eye is often very difficult on account of fear, obstinacy, photophobia, spasm of the orbicularis, and so on. The child's head should then be firmly held between the surgeon's knees (protected by a towel) while its body is laid across the lap of an attendant, who must also hold its hands and arms. The lids can then be separated by the fingers, or, if not, the upper one may be raised by an elevator. If this is not sufficient, or if the eye is drawn out of view by spasm of the superior rectus, the patient should be etherized or cocain freely instilled. It is always best to make a satisfactory examination at the outset, no matter how difficult or inconvenient it may be to do so. The elevator is sometimes required in other cases, where there is great swelling or inflammation of the upper lid.

Great care should be taken in inserting the elevator, especially in purulent ophthalmia, when ulcers exist, lest the cornea be ruptured by the force used and the struggles of the patient.

Redness of the Conjunctiva: How its Character may be Differentiated.

When the front of the eyeball is *red*, it is important to know whether the congestion is superficial or deep. In the former case, the redness will be conjunctival, and will be shown by a coarse network of vessels running over the sclerotic, or by a more uniform redness which nearly con-

ceals all the white part of the globe. If the congestion and swelling are not very great, the edge of the lower lid rubbed against the globe by the finger may be seen to move the vessels over the sclerotic, and to press the blood out of them. The inner surfaces of the lids will be congested also, and there will be a mucous or muco-purulent discharge, probably without much photophobia. In *deep congestion (ciliary congestion)* there is a rosy zone of fine, straight vessels radiating from the edge of the cornea; they are immovable, and can be seen by close inspection to lie *beneath* the conjunctiva in the sclerotic. With this form of congestion, although it may be very slight, there will usually be found pain, dread of light, and a profuse flow of hot tears. This group of symptoms constitutes *ciliary irritation,* and it indicates an affection of the cornea or of some of the deeper tissues. The two kinds of congestion are often found combined. When the exit of the venous blood from the interior of the eye is impeded, large, dark, tortuous veins may appear running over the sclerotic, which they penetrate near the edge of the cornea. In certain cases of inflammation, it is important to know whether there is tenderness in the ciliary region—the region immediately surrounding the edge of the cornea. To test this point, have the patient look downward or upward, and make gentle pressure over this region with the tips of the forefingers placed against the lid.

The discovery of cocain (Koller) as an ocular anesthetic has rendered the examination of the eyes with photophobia much easier than formerly. A few drops of a 2-per-cent. solution instilled every two or three minutes will in a very short time enable one to examine the most sen-

sitive eyes. In instilling cocain for the purpose of quieting the eye a large quantity of cocain hydrochlorate should be used—say, 8 or 10 or even more drops of the 2-per-cent. solution at each application.

Oblique illumination is very useful for examining the cornea, the anterior chamber, iris, pupil, lens, and even the most anterior part of the vitreous, as it shows minute details which escape the naked eye. To produce it, focus daylight or lamplight upon the eye with a 20-diopter convex lens. If a lamp is used, it should be at one side and somewhat in front of the eye examined, on a level with it, and about two feet off. The observer's eye should be in the path of the reflected rays. By moving the lens, the cone of light may be made to traverse all parts of the cornea. The appearances may be magnified by looking through another strong convex lens held directly in front of the examined eye.

The shape and movements of the pupil should be carefully noted. The latter are best observed by excluding the fellow-eye with a towel or the like, and then alternately shading and uncovering the examined eye with the hand. The pupil should contract promptly when exposed to a bright light, and dilate more slowly when shaded—always retaining its circular shape. If inflammatory adhesions between the iris and the lens are suspected, the use of a solution of atropin, homatropin, or euphthalmin will decide the question. If adhesions exist, the pupil will be dilated by the atropin irregularly, or perhaps not at all. Observe the depth of the anterior chamber—whether the iris seems pushed forward or the reverse.

The *intra-ocular* tension, which is very important as an index of the intra-ocular pressure, is estimated by the degree

of hardness of the globe, although this is influenced also by the elasticity of the sclerotic, and varies somewhat in health. The normal resistance gives a sensation which cannot be well described. The tension in disease varies between extreme softness and stony hardness. To test the tension, direct the patient to look down with his eyes closed, and placing both forefingers upon the upper part of the globe, make pressure and counter-pressure, much as when testing for the *sense of fluctuation.* Always compare the two eyes. Bowman's signs are Tn for normal tension, T + 1, T + 2, and T + 3 for successive degrees of increased tension; T — 1, T — 2, and T — 3 for degrees of decreased tension; and the sign of interrogation used in case of doubt. Instruments for measuring the tension are called *tonometers,* but they are not necessary.

The Acuteness of Vision (V or S[1]).

It is supposed that the normal eye sees distinctly under a visual angle of five minutes, the visual angle being that inclosed between two lines drawn from the extremities of the object to the optical center of the eye. The acuteness of vision is estimated by Snellen's *test-types,* which are so constructed that each number should be seen at corresponding distance under an angle of five minutes—No. 100 at 100 feet, No. 20 at 20 feet, etc. It is customary to test the acuteness of vision at a distance of 20 feet. The formula is $V = \frac{d}{D}$ in which *d* equals the distance at which letters are seen, and *D* the distance at which they ought to be seen.

[1] German, *Sehscharfe.*

Thus, if type No. 20 is seen at 20 feet, $V = \frac{20}{20}$, or 1, the normal standard. If type No. 50 is seen only at 20 feet, $V = \frac{20}{50}$. If No. 100 is seen only at 5 feet, $V = \frac{5}{100}$, etc. For the illiterate, figures, constructed on the same principle, are used. When V is so reduced that type cannot be read, it is tested by the ability to count fingers. The distance at which fingers can be counted is noted. Thus, V = fingers at 2 feet, etc. If this cannot be done, there may still be *perception of light—qualitative* when there is some perception of form and outline, or *quantitative* when only difference between light and dark is appreciated. If there is a refractive defect it should be corrected by glasses to obtain the full value of vision.

If the metric system be preferred for the testing of vision, Snellen's letters may still be used. The largest letter in Snellen's test card—seen at 200 feet with normal vision—will be seen at 40 meters; the next in size, 35 meters, and so on at intervals of 5 meters until those which subtend an angle of 5 minutes at 5 meters are reached. If the patient can read the 5-meter type at 5 meters, the vision is registered as $\frac{5}{5}$ or V = I. If only able to read the 30-meter type at 5 meters the vision is $\frac{5}{30}$ or $\frac{1}{6}$ and so on.

The Range (or Power) of Accommodation.

$\frac{1}{A}$ expresses the power of the eye to adjust itself for divergent rays, such as come from near objects. It is found by the formula $\frac{1}{A} = \frac{1}{P} - \frac{1}{R}$ in which *P* equals the distance of the nearest point *(p)* of distinct vision, and *R* the distance of the farthest point *(r)*. It is really represented by that convex lens which, if placed at the nodal point of the eye,

would give to rays coming from p a direction as they came from r. For determining p and r it is customary to use Snellen's or Jaeger's test-types, selecting the smallest that can be distinctly seen. Although all rays which strike the eye are really divergent, those coming from an object 20 feet or more distant are regarded as practically parallel, and such a distance is called *infinite*. An eye which sees with *perfect distinctness* at 20 feet or more is said to have its far point in infinity. An emmetropic eye when at rest is adjusted for parallel rays; its far point lies in infinity, $\frac{1}{D} = \frac{1}{\infty}$. If it can still see distinctly to within a distance of 6 inches, its near point lies at 6 inches, and $\frac{1}{A} = \frac{1}{6} - \frac{1}{\infty} = \frac{1}{6}$, or a convex lens of 6-inch focus. The accommodative power of such an eye is always expressed simply by $\frac{1}{P}$. A hypermetropic eye may also see distinctly at an infinite distance, but only by exercising a part of its accommodation; for near objects it must use *more* accommodation than the emmetropic eye. Its total accommodative power is expressed by $\frac{1}{P}$ *plus* the amount of hypermetropia. Thus, if $H = 1.50$ D, and the near point lies at 8 inches, $\frac{1}{A} = 4.50 \text{ D} + 1.50 \text{ D} = 6$ D. In a myopic eye the far point corresponds to the myopia; the eye *at rest* is adjusted for divergent rays; for near objects it uses less accommodation than the emmetropic eye, and its accommodative power is $\frac{1}{P}$ *minus* the myopia. If the far point lies at 12 inches—that is, if $M = 3$ D and the near point lies at 4 inches, $\frac{1}{A} = 9 \text{ D} - 3 \text{ D} = 6$ D. Thus, in the three examples the accommodative power is the same in each, although the near point is different. We distinguish: 1. The absolute range ($\frac{1}{A}$), where one eye is used.

2. The binocular range ($\frac{1}{A_1}$), where both eyes are used.
3. The relative range ($\frac{1}{A_2}$), or the range commanded while the convergence of the visual lines remains unaltered, embracing *(a)* the *positive* part, lying within the point of convergence, and *(b)* the *negative* part, lying beyond the point of convergence. To test the relative range, we may place the object at a definite distance,—say, 12 inches,—and find through what convex and concave glasses it can still be clearly seen. The glasses alter the accommodation without affecting the convergence—the convex measuring the negative part of the relative range, and the concave the positive part, or the accommodative force held in reserve. To do near work comfortably the positive part should be to the negative as 3 to 2.

The region of accommodation is the distance between the farthest and nearest points of distinct vision. Thus, if *r* lies at 30 inches and *p* at 5 inches, the region is 25 inches. With the same range the region may vary greatly.

Determining the Refraction.

THE OPHTHALMOMETER.

It is necessary to use the ophthalmometer (Helmholtz, Javal, nineteenth century) as soon as the vision has been determined. This instrument decides whether or not corneal astigmatism exists, and, if so, what are its degrees, and the meridian of the cornea at fault. By its aid the surgeon may, except in extremely exceptional instances, avoid the use of a mydriatic or cycloplegic, for the purpose of paralyzing the accommodation as is necessary in skiascopy or retinoscopy. The ophthalmometer having determined whether or

not corneal astigmatism exists and its axis, the conditions are noted for use in testing for glasses.

TRIAL GLASSES.

To continue the tests of the vision it is necessary to have a case of trial glasses, comprising convex and concave spherical and cylindrical lenses. The rays of light are rendered convergent by the convex and divergent by the concave spherical glasses. The cylindrical lenses act like corresponding spherical glasses in one meridian, and like plane glasses (not bending the rays at all) in the meridian at right angles to this. The latter is called the *axis* of the glass. The strength of a lens was formerly expressed by a fraction whose numerator is one and whose denominator is the focal length of the lens in inches, the *plus* sign being prefixed to the convex and the *minus* sign to the concave. Thus, $+ {}^1/_6$ represents a convex lens of 6-inch focus; $- {}^1/_6$ a concave lens of 6-inch focus. The dioptric system has displaced the old method of estimating the power of glasses. It is much more convenient, although it gives no idea of the focal power of lenses. By the dioptric system the unit is taken at one diopter. For instance, a convex glass of 1 diopter (1 D) is one of sufficient power to converge parallel rays of light to a focus at a distance of 1 meter (a meter equals 36 French inches and about 40 English inches). The shorter the distance or focus, the stronger the glass—*e.g.*, a + 2 D glass would focus parallel rays at ${}^1/_2$ meter, and + 4 D at ${}^1/_4$ meter, etc.; ${}^1/_2$ diopter (0.50 D) would focus parallel rays at 2 meters. Thus we have fractions of diopters—*e.g.*, 0.25, 0.50, 1.25, 1.50 D, and so forth, up to the strongest lenses of

the old system. The advantage in making additions and subtractions is readily seen. Cylindric lenses are designated in the same way, with the addition of a *c* placed after the fraction. Each eye should be tested separately; the eye not being tested is shaded with a screen without making any pressure upon it. If the patient has normal acuteness of vision, not improved by convex or concave glasses, he may be assumed to be *emmetropic.* If the vision is below normal and improved by concave glasses, he is probably *myopic,* and the glass which gives him the best vision expresses approximately the degree of his M. Young persons, however, sometimes readily accept or see better with concave glasses when they actually are hypermetropic (see "Spasm of Accommodation"). If he sees best through convex glasses he is *hypermetropic,* and the glass which affords the most acute vision expresses his *manifest hypermetropia,* a part of the defect, called *latent hypermetropia,* being almost always concealed by the habitual use of the accommodation. Sometimes the whole hypermetropia is latent; the patient may have normal acuteness of vision and reject all glasses, or he may even appear to see better through concave glasses, so exalted is the action of the ciliary muscle. Latent hypermetropia may always be made manifest by applying a solution of atropin (4 grains to 1 ounce) several times before the examination; it may also be detected with the ophthalmoscope. If, however, the presence or absence of corneal astigmatism and its degree and axis be determined, it is not at all necessary, except in highly exceptional cases and children under 10 years of age to use any cycloplegic. It is seldom necessary even in children. The use of these agents should be avoided whenever possible. If astigmatism exists

it should be corrected according to the rules that will be given later before the existing myopia or hypermetropia is tested with the glasses. Very often the sight cannot be raised to the normal standard with any glass, and then amblyopia *(weak sight)* is associated with the other conditions.

The Field of Vision.

This is bounded by the most eccentric points which can be perceived while the visual line remains fixed upon a central point; it comprises the parts seen *indirectly,* around the central object seen *directly.* To test it, place the patient about 12 inches from a blackboard, and have him direct the eye to be examined (the other one being covered) toward a small dot or cross marked in the center of the board. Take a piece of chalk fastened to the end of a stick, and advance it slowly from the edge of the board, and mark the spot where it is first seen—not as chalk, but merely as something white coming toward the eye. Repeat this in every direction, and join the marks by a line. This maps out the *quantitative* field. By marking in the same way the points where the patient can first *recognize* the approaching object—as, for instance, to count fingers—the *qualitative field* is obtained. By using bits of colored paper as objects, the different color fields are obtained. In the normal eye blue has the largest field, yellow the next, red and green the next. *It is essential in these tests that the patient keep his eye fixed upon the central dot during the whole examination.* If vision is reduced to the perception of light, the patient is made to keep his eye directed straight forward, and a lighted candle is used in the same way as the chalk, to determine the limits of the field. The candle should be shaded with the hand

when carried from one point to another, so that the patient will not know from what direction to expect its appearance. A convenient and rapid way of testing the field is as follows: Place yourself two feet away from the patient, with your eye on a level with his, and directly in front of it; if testing his right eye, for example, have him look steadily with this into your left eye, the other eye of each being closed; then, by using the test-object midway between—that is, a foot from each—you can map out the patient's field, and at the same time compare it with your own, which is supposed to be normal.

The field may be concentrically or irregularly contracted or interrupted by scotomata (Gr. *σκοτός*, darkness), or blind spots. To test for scotomata, carry the object from various parts of the periphery of the field quite up to its center, and observe whether there are areas where it is indistinct or where it disappears from view altogether. Sometimes the right or left half of each field is wanting—*homonymous,* or *equilateral, hemiopia* (Gr. ἡμι, half, and ὄψις, vision). Sometimes the outer half of each field is lacking—*temporal hemiopia;* sometimes the inner half—*nasal hemiopia.* In the normal field there is always a blind spot, corresponding to the optic disc, where the fibers are insensible to light. This is called the blind spot of Mariotte, after the man who first described it (Mariotte, France, seventeenth century). Under ordinary circumstances it is not noticed, and occasions no inconvenience. Each point of the field corresponds to an opposite side of the retina. There are several forms of perimeters *(peri, metron)* used for measuring the visual field. One of the best is Emerson's. Charts for recording the results of the examination go with the instruments.

Color-Perception.

The perception of colors may be defective congenitally or from disease. It is best tested by worsteds representing the ordinary primary colors and their different shades. A skein of worsted representing one of the primary colors—for instance, green—is laid out, and the patient is directed to put beside it all the samples which seem to him to be of the same color. The other primary colors are used in the same way. Tests which simply require the patient to name the colors are not considered reliable, for the reason that the color-blind learn to name colors correctly from the intensity of their illumination, etc. The worsted test is known as Holmgren's (Holmgren, Sweden, nineteenth century). Lanterns are also used for testing color-blindness. Useful ones have been designed by William Thomson, Charles H. Williams, and Eldridge Green.

As demonstrated by the late Professor Rood, of Columbia College, New York, the capacity to distinguish colors varies as much among the human race as does the power of vision. But it is only when subjects are much below the average standard and cannot, for example, tell green from red that the color-sense requires investigation.

Central and Eccentric Fixation.

It should be observed whether the object is looked at directly or indirectly. In the former case the image is formed at the yellow spot, and there is said to be *central fixation;* in the latter case the image is formed on some other part of the retina, and there is *eccentric fixation.* In eccentric fixation the patient presents the aspect of looking at

objects "out of one corner of his eye," as it is commonly expressed.

Having examined each eye separately, it is necessary to find whether the two eyes work in harmony. To do this it is essential to understand the significance of diplopia and the action of prisms.

Diplopia, or Double Vision.

(Gr. διπλοῦς, double, and ὄψις, vision.)

If both visual lines are not fixed upon the object, the images are formed on different parts of the two retinæ and there is *diplopia,* or double vision. For example, if the right visual line is fixed upon an object, while the left is deviated inward, the latter's image falls upon a part of the retina *inside* of the yellow spot, and is projected to the outer side in the field, so that it is seen on the left side of the other image. This is *homonymous diplopia,* each eye seeing its image on the corresponding side. If one eye deviates outward, the conditions are reversed, and there is *crossed diplopia,* the right image belonging to the left eye, and *vice versa.* If one eye turns upward, its image appears beneath that of the other, etc. In short, the double image always appears in a direction opposite to that in which the eye deviates. The images may be parallel or inclined to one another. The image of the deviated eye is called *false,* that of the normally directed eye being the *true* one. The false image is fainter from being formed on a part of the retina outside of the macula, and therefore less sensitive. When the images stand near together the false one is very distinct and causes intense discomfort; when far apart, it is fainter

and produces little or no annoyance, as the patient soon ceases to notice it. A disc of red glass may be held before one eye to color one of the images, and so aid the patient in distinguishing them. A candle-flame is one of the best test-objects. Diplopia may be constant, when there is fixed squint, or may only appear when the eye is moved in certain directions, as when there is only slight insufficiency of a single muscle. The slightest form of it is where the images are superposed and the object appears surrounded by a halo. In certain refractive defects there may be two or more images formed in a single eye, causing *monocular diplopia,* or *polyopia.*

Prisms.

A prism bends the ray of light in the direction of its base according to the size of its angle. If, while regarding an object, a prism is placed before one eye with its base inward, the rays from the object will be deviated inward and the image will be formed on the retina inside of the macula; there will be homonymous diplopia. The eye will instinctively try to overcome this by rolling outward, so as to bring the image again upon the macula, and single vision will thus be restored, provided the prism is not too strong. Prisms are much used for testing the strength of the muscles, the strongest one which can be overcome by them being taken as a measure of their power. For example, if, while looking at an object 12 feet distant, beginning with a prism of 1 degree and increasing its strength 1 degree at a time until a prism of 8 degrees, with apex outward, can be placed in front of one eye (or a prism of 4 degrees, apex outward, in front of each eye) before ability to fuse the double images

is lost, we may consider that prism as the measure of the power of the external recti at the distance named. The strength of the internal recti, superior recti, and inferior recti is measured in a similar manner—that is, by beginning with a weak prism, apex over the muscle to be tested, and increasing it until the patient cannot fuse images. Thus, also, where there is diplopia, the strength of the prism required to fuse the images becomes a measure of the degree of deviation of the visual lines. For example, if there is a crossed diplopia, and the images are united by a prism of 15 degrees placed before one eye with the apex outward, we say that there is weakness of the internal recti of 15 degrees. The eyes are able to unite double images widely separated laterally, but cannot unite those showing more than very slight difference in height. If a prism of 10 degrees, base upward or downward, is placed before one eye, a diplopia is thus produced which cannot be overcome; the impulse for single vision is annulled, and the eyes yield passively to muscles which happen to be strongest.

Testing the Power of the Muscles.

To examine the action of the muscles, the patient may be directed to look at a pencil and to follow it with both eyes, without moving his head, while it is carried slowly in various directions through his circle of vision. If a muscle is inefficient, one eye may often be seen to waver and lag behind its fellow when turned in the direction of such muscle's action. For example, if the right *externus* is weak, when the pencil is moved to the patient's right side the left eye will follow it, but the right eye will not, or will do so in an uncertain, faltering manner. To test the *internal recti* as

to their converging power: 1. The patient may look at the pencil with both eyes while it is gradually advanced to within 4 or 5 inches, the surgeon observing whether they remain fixed upon it or deviate outward. 2. While both eyes are fixed upon the pencil, one may be covered by the hand so as to exclude it from vision, but still allow of its being watched; if its *internus* is weak it may be seen to roll outward as soon as its visual sensation is thus cut off. 3. Draw a fine vertical line upon a piece of white paper, and in the middle of the line make a round, black dot $^1/_8$ inch in diameter. Let the patient look at it, while a prism of 12 degrees, base upward or downward, is held before one eye. Two dots, one above the other, will then be seen. If the muscles are normal the dots will be on the same vertical line; if the *interni* are weak, they will be separated laterally and *crossed,* that of the right eye being on the left side and *vice versa;* in the latter case, by placing other prisms, base inward, before the eye, the dots may be brought into the same vertical line; and the strength of the prism required for this measures the deviation (or weakness of the interni) which is present. If the images are separated laterally, and homonymous, it shows deficient action of the *externi;* prisms placed base outward before the eye will bring them into the same vertical line, the prism required measuring the muscular weakness. The insufficiency of the superior and inferior recti muscles may be measured by first causing a horizontal diplopia with prisms base inward. If the right image is higher than the left, it shows a deviation downward of the right eye or upward of the left. The strength of the prism, base up in front of the right or down in front of the left, necessary to bring the images on a level measures the

degree of insufficiency. A candle may be used instead of a dot when the muscles are to be tested while the patient is looking in the distance—say, 20 feet. The most common defect of muscular equilibrium is ordinary *squint,* which is generally discovered at a glance (*vide* "Strabismus").

Great caution should be exercised in making deductions from the use of prisms in estimating the power of the ocular muscles. Especially is this so when the tests are made as above described—that is, by first causing a diplopia in the vertical plane in order to test the horizontal muscles, and a diplopia in the horizontal plane to measure the vertical muscles (Graefe test). The most accurate method of measuring the strength of the ocular muscles is the simple adduction, abduction, and sursumduction test. That is, to measure adduction begin with a prism of 1 degree apex over the internal rectus and increase it until the patient can no longer fuse the images. The strongest prism with which they still fuse the images measures the power or strength of the muscles. The abduction is measured by placing the apex of the prism over the external rectus, and the sursumduction, right and left, by placing the apex of the prism over the superior recti muscles, respectively. As a guide to follow we may take the results obtained by Bannister,[1] who examined one hundred soldiers as a standard, who, of course, were sound both as to body and had normal vision without the use of glasses. The average adduction was 14 degrees; abduction, 7 degrees; and sursumduction, right and left, 2 degrees. Any considerable deviation from this standard may indicate abnormality and call for treatment.

[1] "Dynamics of the Ocular Muscles," *Annals of Ophthalmology,* January, 1898.

All refractive errors should be corrected before testing the strength of the muscles, as most insufficiencies are dependent upon an error of refraction, and the proper correction of the error of refraction is the most important measure in the treatment of muscular insufficiencies. As a matter of routine the strength of the ocular muscles may be tested, so that we may know the actual conditions present. We attach no great importance on slight or even considerable variation in the strength of the ocular muscles, as different results are often obtained at different examinations, and patients learn by practice to overcome prisms and see single with those which, on the first trials, produced double vision. If the general strength of the patient is looked after and proper hygienic surroundings observed, these, with proper glasses, are all that is needed to relieve most muscular insufficiencies. Too exact study of the power of the ocular muscles has led to much erroneous teaching and practice.

Binocular Vision.

(Lat. *bis*, twofold, and *oculus*, eye.)

It is important to know whether this exists. A simple test is to hold a pencil midway between the eye and the print, while reading. If there is binocular vision, the pencil will not interfere with the view of any part of the page; but if only one eye is used, the pencil will obscure the view just in proportion to its size. Or, both eyes being open, hold a prism, base upward or downward, before one eye, and if diplopia appears, this proves the existence of binocular vision. Some eyes become so different through disease, or are of such different construction congenitally, as to be independent or-

gans, binocular vision having ceased or never having existed. A stereoscope, of which there are many useful and low priced varieties sold by the opticians, is very useful as a means of determining the existence of binocular single vision.

The Ophthalmoscope.

When light enters the eye a part is absorbed and a part reflected outward again through the pupil. The reflected rays retrace precisely the course by which they enter. To see the fundus oculi, the observer's eye must be placed in the path of these rays, without intercepting the source of light. Ordinarily this would be impossible. The difficulty is overcome by the ophthalmoscope (Gr. ὀφθαλμός, eye, and σκοπειν, to look), invented by Helmholtz, 1851. The instrument consists essentially of a small plane or concave mirror by which light is thrown through the pupil so as to illuminate the retina and choroid. Lenses for estimating the refraction are on a disc on the back of the mirror. The examination should be made in dark room, with a bright, steady light placed at the side of patient's head, corresponding with the eye to be observed, on a level with the latter and a little behind it, so that it will be in shadow. The light is received upon the mirror and reflected thence into the observed eye. The mirror thus becomes a source of light, and the observer's eye placed behind the perforation can be directly in the path of the rays reflected from the fundus of the eye observed. The pupil may be dilated if necessary: (1) by a solution of euphthalmin (gr. xx to ℥j); (2) by a weak solution of atropin (gr. j to ℥j); or (3) by a solution of cocain (gr. viij to ℥j). The observer should endeavor to examine without a mydriatic, as far as possible. There are

two methods of examination; the *indirect* (or by the inverted image) and the *direct* (or by the erect image). In the former, the surgeon holds the mirror close before his eye, and the illuminated eye is observed from a distance of about 12 inches; with the other hand a 20 D biconvex object lens is held vertically before the observed eye and about 1 inch in front of it; the lens may be steadied by resting a finger against the patient's forehead, and another finger may be used to raise the upper lid if required. An enlarged inverted image of the fundus is thus formed between the lens and the observer; the image may be further magnified by placing a 3 to 4 D convex lens behind the mirror of the ophthalmoscope. The optic disc is best brought into view when the patient directs his eye a little toward the nasal side of the center; the macula, when he looks straight ahead. In the *direct method* no object-lens is used, and the observer approaches to within 1 or 2 inches, using the eye corresponding to the one he examines, and relaxing his accommodation as if he were looking into infinite distance. The image is erect, and apparently *behind* the patient's eye; it is larger than the inverted image, but the field of vision is smaller. The direct method is preferable for minute and accurate examination of details, the indirect for a general survey of the whole fundus.

In examining an eye with the ophthalmoscope, after carefully looking at the cornea, the media should be first observed from a distance of from 12 to 18 inches. If the observed eye is moved in all directions, and especially if the pupil is also dilated, no opacity of the media need escape detection. For detecting very minute opacities, a magnifying glass of 3- or 4-inch focus may be used behind the ophthal-

moscopic mirror, taking care to have the part examined about at the focus of the glass. With the ophthalmoscope, opacities of the media usually appear black against a red background, while by oblique illumination they have a grayish aspect.

If the media are clear, the pupil is filled by a brilliant yellowish-red reflex from the retinal and choroidal vessels, which is more or less modified by the amount of pigment present. The appearances of the fundus vary greatly within the limits of health. The optic papilla generally appears as a round or vertically oval disc, about $^1/_7$ inch to the inner side of the posterior pole, slightly prominent, of yellowish-white color (most marked on the inner half), often bordered by pigment and by a whitish connective-tissue ring, and marked by white striæ from trabeculæ of the lamina cribrosa. The central vessels radiate from its center into the retina, the arteries being of bright color and straight course, with light-streak along the center; the veins larger, darker, and more tortuous. *Venous pulsation* often appears on the disc, or, if not, is easily produced by slight pressure upon the globe. *Arterial pulsation* is not observable in the normal states. Near the center of the disc is a white, glistening *physiological excavation,* generally small and shallow, with sloping edges over which vessels are seen to dip; sometimes it is large or has sharp edges. The retina is too transparent to be easily seen; it is seen best in dark eyes, especially in those of negroes, where it may appear as a grayish film. The *macula lutea* should be found 2 diameters of the disc to the outer side of the same and on a level with its lower half; it appears as a roundish spot, more deeply colored than the rest of the fundus, with a bright-yellow spot, the *fovea*

centralis, in its center. The region is marked by the absence of blood-vessels. The pigmented cells may be seen as small dots uniformly studding the fundus, and giving it a granular appearance. In light eyes vessels of the choroidal stroma may be seen as bright-red bands inclosing intervascular spaces, and even finer vessels and venæ vorticosæ may appear. In dark eyes the choroidal vessels may be completely hidden and the fundus may have a mosaic appearance (choroidat tigre) from abundance of pigment.

In what has been said of the *direct method* it has been assumed that the eyes of both the patient and the observer are emmetropic, and with the accommodation relaxed—that is, *adjusted for parallel rays.* Then, rays which emerge from the illuminated fundus of the patient's eye and enter the observer's eye are parallel, and the latter obtains a distinct image, although the object is but 2 or 3 inches away. If the eye observed is not in the condition assumed, the direction of the rays is altered accordingly and the image naturally indistinct. In myopia the emerging rays are convergent; a concave glass must be placed behind the hole in the mirror to render them parallel before entering the observer's eye, in order to give him a clear image. In hypermetropia a convex glass must be similarly used. The glasses thus required to give a clear image—that is, to render rays parallel, as in emmetropia—become also a measure of an existing departure from emmetropia, or of the refractive defect. If the observer is not emmetropic, he can correct his defect by a proper glass, and then proceed as if he were emmetropic. If he cannot fully relax his accommodation, he is practically myopic to the degree used—that is, his eye is adjusted for divergent rays. The degree used is generally the same, and

can be found by experiment. Having found this, the observer should proceed as if he had myopia of that degree. In making calculations the observer's defect must always be allowed for.

Such, in brief, are the principles on which the direct method becomes so useful for measuring the refraction of the observed eye. It is a valuable aid to other means, not a substitute for them. This method is also used for making measurements in the depth of the fundus, as of inflammatory swellings, tumors, and so forth, on the principle that a certain refraction corresponds to a certain length of antero-posterior axis. For a full explanation of the whole subject see Mauthner's "Lehrbuch Ophthalmoscopie," Chapter VI, or a "Text-book of Ophthalmoscopy," by the late Dr. Loring. An ophthalmoscope for estimating the refraction of the eye contains numerous convex and concave lenses. Loring's instrument was the first practical one. The disc fits upon the back of the mirror, and by rotating it any glass required can be brought opposite the sight hole.

Very many modifications of the Loring instrument have been made by various ophthalmologists, but, with the exception of the addition of a tilting instead of a fixed mirror, none of them have any particular advantage over the Loring instrument. After Wadsworth's suggestion, Loring changed his fixed mirror to a tilting one. Recently Dr. Dennett and H. L. de Zeng have perfected electric ophthalmoscopes, which are the ordinary Loring ophthalmoscopes with electric lights within. They are very easy to use, as the light moves when the instrument moves, and are especially useful at the bedside and examining the eyes of small children, and babies. A small battery is necessary for the use of the instruments.

THE THERAPEUTICS OF THE EYE.

These comprise both local and general means. The latter are very important. Many ocular diseases result from syphilis, rheumatism, Bright's disease, gout, and will not recover without appropriate general medication.

ASEPTIC PRECAUTIONS IN EXAMINATIONS.

The surgeon's hands and instruments should be scrupulously clean, and never carried from one eye to another without washing in sterilized water. It may be sufficient to clean the hands with soap and water and the nail-brush, but many operators immerse them in a solution of bichlorid of mercury, 1 to 1000, for a period of two to five minutes after washing the hands thoroughly. All the instruments, except knives and scissors, should be sterilized by subjecting them to great heat in a sterilizer. The cutting instruments should be dipped in alcohol for two minutes and then in boiling water for two minutes. Poultices are a very common application among those who prescribe for themselves, and are almost always injurious. As a rule, they should be avoided. Lead lotions are dangerous, as, in ulcerative diseases of the cornea, they may be deposited as insoluble precipitates in the corneal tissue, forming white opacities. Absolute cleanliness; good hygiene; rest of the eyes; and avoidance of bright light, wind, dust, smoke, and so on, are prescriptions of almost universal application in ocular diseases. In syphilitic affections the mercury is often given by inunction or hypodermically to secure a rapid effect. Anodynes are used, as in disorders of other parts of the body. The following *local* measures are of very extensive use:—

THE PROTECTIVE, OR COMPRESS, BANDAGE.

This is used to exclude the eye from injurious influences, to support it, and to keep it at rest. To apply it, lay a small piece of soft linen over the closed lids, and upon this spread charpie or cotton enough to fill the orbital hollow, regulating the amount according to the object in view, and being careful to distribute it in such way that its pressure will be uniform. This is held in place by a flannel roller, 1 $^1/_2$ inches wide, applied by alternating turns, first around the forehead and then down under the occiput and over the eye. Instead of flannel, gauze may be used in many cases. *Crepė de Velpeau,* a very flexible material, makes a very good bandage, especially after an operation for cataract. It is pleasanter to the patient than flannel. All these applications should be made aseptic by hot air before being used.

EYE-SHADES.

They are often used as a protection from light and wind. They are best made of thick paper or pasteboard covered with black silk and fastened by tape running around the head.

PROTECTIVE SPECTACLES.

These are of various kinds. Those with wire sides which exclude ventilation and keep the eye confined in an atmosphere of its own exhalation are objectionable, except for very windy places.

THE HERMETICAL BANDAGE.

This is sometimes needed to protect the sound eye from contagious discharges of the diseased eye. Several different

forms are used. A simple method is to cover the eye with a piece of soft linen and pad of charpie; fasten this with plaster and cover with collodion. Or charpie may be covered with a piece of oiled silk, and over this a piece of linen, the whole coated with collodion and fastened by it to the skin at the edges. Buller's shield consists of a watch-crystal held between two square pieces of adhesive plaster, holes being cut in the center of the plaster (Buller, Montreal). The outer piece of plaster (on the convex side of the crystal) is larger than the inner, and can be stuck to the nose and face. The temporal side is not pasted down, so that air can reach the eye. All these applications must be in a sterile condition before use.

LOCAL BLOODLETTING.

This is accomplished by natural and artificial leeches. They are applied to the temples about an inch from the outer canthus, or farther back among the hairs (which are first shaved) if it is necessary to hide the scar. The effect of the artificial leech is revulsive, and the vision is sometimes worse immediately after. After-bleeding from leeching should be encouraged by warm applications, and the patient kept in a darkened room for the ensuing twenty-four hours or the eye bandaged.

COLD APPLICATIONS.

The best method of making them is to have pledgets of wet sterilized absorbent cotton spread upon a cake of ice. One of these may be laid over the eye and changed for another as soon as it becomes warm. The pledget generally needs to be changed every two or three minutes. They

should not be so wet as to allow water to trickle over the patient's face and down upon his clothing. Dry cold may be applied by a small rubber bag filled with pounded ice. Generally such applications are uncomfortable on account of their weight.

The *cold douche* is chiefly used for children who present great spasm of the orbicularis muscle and photophobia. The child's body and arms are firmly held while its face is forcibly dipped into a basin of cold water just enough to submerge the eyes, and is held there for a few seconds. The dipping may be repeated several times in quick succession.

HOT APPLICATIONS.

They are also made by pledgets of absorbent cotton wrung out of hot water, or by holding hot water against the eye with the hand, or the eyecup.

Heat and cold are not usually applied continuously, but rather for periods of from ten to twenty minutes, at intervals of an hour or more. Cold is usually proper at the onset of acute external inflammations. Beyond this it is difficult to give absolute rules for their use, the patient's *sensations* being as safe a guide as any.

MYDRIATICS.

These are agents which enlarge the pupil and most of them paralyze the ciliary muscle. The *sulphate of atropin* (active principle of belladonna) is a type of this class, and is the one most used. It contracts the blood-vessels and paralyzes the sphincter of the pupil and ciliary muscle, and puts the eye in a state of complete physiological rest. It is

applied directly by being dropped from a dropper into the lower conjunctival sac, or penciled upon the inner surface of the lower lid with a very small bit of absorbent cotton. It is absorbed through the cornea and conjunctiva, and the effects appear in a few minutes and last several days. It acts on the peripheral ends of the nerves, paralyzing the filaments of the oculomotor and stimulating those of the sympathetic (?). The pupil first dilates, and then the accommodation gradually becomes paralyzed. The form employed is a solution of gr. i-iv to water ℥j, and this is sufficient for all ordinary uses. A very weak solution (gr. $^{1}/_{8}$ to ℥j) dilates the pupil without much effect on the accommodation, and is thus useful for making ophthalmoscopic examination, but euphthalmin is to be preferred (gr. xx to ℥j). Ointments containing atropin may also be used. The patient should always be told beforehand of the effects of the drug, lest he be frightened and accuse the oculist of "putting out his eyes." In some cases atropin has a poisonous effect, shown by increase of inflammation, pain, irritation of the lids and conjunctiva, eczematous eruption, etc., and must be discontinued ($^{1}/_{2}$ grain of sulphate of zinc added to each ounce of the solution will often prevent this). Its local use often causes unpleasant feeling of dryness and constriction in the throat. Very rarely it causes alarming symptoms of belladonna poisoning. Scopolamin is a drug that may be substituted for atropin, gr. ss-j to ℥j; also homatropin, gr. xv to ℥j. Morphin is a proper antidote in case of poisoning by these drugs.

DUBOISIN.

This drug (the active principle of *Duboisia myoporoides*) produces the same effects as atropin, but acts more powerfully. It is used in solutions of the same strength as atropin, and is often substituted for that drug when atropin causes poisonous symptoms.

HYDROCHLORATE OF COCAIN.

This drug, which is chiefly used as a local anesthetic in operations upon the eye (Koller, 1885), is also valuable as a mydriatic, especially when very temporary effects are desired, as in ophthalmoscopy. A solution of from 8 to 16 grains to the ounce may be used, or, if preferred, in gelatin discs. It may be used more freely than atropin, but, since it removes or dulls the epithelium very rapidly, a little caution is necessary, when it is employed for some moments, to keep the cornea moist by rubbing the lids over the eye or the use of water.

EUPHTHALMIN.

This drug is extensively used where it is necessary to dilate the pupil for an ophthalmoscopic examination. This is a pure mydriatic and does not affect the ciliary muscle. It is used in solution of gr. xx to ℥j.

MYOTICS.

Agents which contract the pupil are of more limited application. Eserin, the active principle of Calabar bean, is a type. It contracts the pupil and causes spasm of the ciliary muscle. It will overcome weak solutions of atropin,

but not a strong one, and its effects are brief. *Sulphate of physostigmin* and *sulphate of eserin*—both alkaloids of Calabar bean—are the myotics most commonly employed. Eserin is useful in much the same cases as atropin, excepting iritis, and it sometimes agrees where atropin does not. It is said to contract the vessels, to lower the intra-ocular pressure, and to lessen diapedesis (*vide* "Glaucoma"). It sometimes causes irritation. Both eserin and physostigmin have been highly recommended for suppurative disease of the cornea.

Pilocarpin (the active principle of jaborandi) is similar to eserin in its effects on the eye, but is not so useful. It is used hypodermically (hydrochlorate of pilocarpin, dose, $^1/_8$ to $^1/_3$ grain) as an alterative and absorbent. It acts very favorably in episcleritis, choroiditis, and for clearing up vitreous opacities. When used in this way it sometimes produces alarming prostration, accompanied by vertigo, nausea, and vomiting. It also causes sweating, salivation, and lacrymation. Its great value in choroiditis is due probably to the excitation of the action of the absorbents. A very small dose should be used at first and gradually increased according to the manner in which it is tolerated by the patient.

Eserin, physostigmin, and pilocarpin are used locally in solutions of 1 to 4 grains to the ounce. Atropinized and calabarized gelatin discs are sold in the shops.

It is sometimes important to use oily instead of aqueous solutions. Less irritation is produced by the latter. Castor-oil is the best vehicle when an oil is used.

IRRITANTS, ASTRINGENTS, AND CAUSTICS.

The following are most commonly employed:—

Powdered Calomel.—This is applied by dusting it into the eye from a camel's hair brush while the lids are held apart by the fingers. The brush should not touch the eye, and the powder should be fine and not used in excess, lest it form lumps and cause too great irritation. Dionin is a strongly irritating powder used in superficial inflammations of the cornea.

Ointments.—*Yellow oxid of mercury,* gr. ii-viij to ℥j, of vaselin, is a very reliable remedy in blepharitis and in phlyctenular keratitis. *Ammoniated* mercury in the same strength is less irritating, while red oxid of mercury in the same strength is much more irritating. The yellow oxid ointment is the best of them all. Zinc oxid ointment is used as a protective to the lids in eczematous conditions.

Solutions of tannic acid and glycerin (gr. x-cxx to ℥j), applied on the inner surface of the lids by probe and cotton or with a dropper, act both as an astringent and an irritant. They are also applied to the edges of the lids for blepharitis, etc.

Protargol, argentamin, and argonin are other new preparations of silver, and are used in solutions of gr. v-xxx to ℥j. They are less irritating than silver nitrate. How far they should be used instead of the old preparations remains to be proven. Aktol, collargol, and itrol are still other preparations of silver which are on trial as yet.

Solutions of nitrate of silver (gr. $^1/_{40}$ to ℥j) are applied to the palpebral conjunctiva with cotton wound on a toothpick or other holder. After making an astringent or

caustic application, it is customary to wash off the surface treated with a little water, or, in case of nitrate of silver, a little salt and water, in order to neutralize any excess of the remedy.

ARGYROL, in from 10- to 50-per-cent. solution, is a new and very valuable agent in blennorrhea or purulent inflammations of the eye. It is less irritating than nitrate of silver and has of late become very popular in the profession.

CRYSTALS OF SULPHATE OF COPPER (bluestone) and of ALUM, cut into smooth and convenient form; equal parts of *sulphate of copper, nitrate of potash,* and *alum, molded into sticks (lapis divinus); mitigated or solid stick of nitrate of silver,* are applied to palpebral conjunctiva by everting the lids. They are used most frequently in trachoma and chronic conjunctivitis.

Lotions or *washes (collyria)* are often given to the patient for his own use at home. The most common astringent collyria are those of sulphate of zinc, alum, or copper, or acetico-tartrate of alum (gr. ss to ℥j). For bathing the eyes, a solution of salt and water, or of borax and water (ʒj to Oj) is very useful, or a saturated solution of boric acid. Where there are irritating discharges and sticking together of the lids, simple cerate, vaselin, benzoinated lard, etc., are given, to be smeared along the edges of the lids.

LOCAL ANESTHETICS.

A solution of the hydrochlorate of cocain, of the strength of from 8 to 16 grains to the ounce, instilled every three minutes for from ten to twenty minutes, is a local anesthetic of the first rank (Koller, Vienna, 1885). It is used in the operation for cataract, artificial pupil, and for-

eign bodies upon the cornea with the best of results, and has largely displaced the use of general anesthetics.

Substitutes for cocain have been found, but they seem to the authors to have no special value over cocain, which as a local anesthetic accomplishes all that can be reasonably desired. Holocain, in 1-per-cent. solution, is a good anesthetic; it also has antiseptic properties and does not peel the epithelium from the cornea; however, it allows more bleeding than does cocain in operative work. Eucain has been tried extensively as a local anesthetic in ophthalmic practice, but is now seldom used on account of its irritating properties.

JEQUIRITY.

The powder or solution of this bean is extremely valuable in bad cases of trachoma with vascular keratitis (pannus). A membranous inflammation of the lids is excited in a few hours by placing a very small quantity—say, $^1/_{120}$ drachm—upon the palpebral conjunctiva (*vide* "Trachoma").

EXCLUSION FROM LIGHT.

The degree of light to be allowed to a case of ophthalmic disease is often an embarrassing question. Many patients shrink from the light, when to indulge their propensity would be ruinous. The tendency of the laity is toward too much exclusion. When eyes are bandaged rooms may be kept light even after operations upon the eyeball for cataract, iridectomy, and so forth. As a general rule, the more light and fresh air, the better for the case, within reasonable bounds.

The Surgery of the Eye.

The following are the principal operations performed on the eye: The lids are held apart, when necessary, by a spring speculum or an elevator under one or both lids, and the eyeball kept in position by a fixation forceps, which should grasp a fold of the conjunctiva near the corneal margin, and be lightly held, so as to steady the globe without any undue traction or pressure.

PARACENTESIS OF THE CORNEA.

This operation is performed by passing a needle or the blade of an iridectomy knife through the cornea near its margin, and allowing the aqueous humor to drain off slowly alongside of the instrument. In this, and all other operations where the anterior chamber is opened, a too rapid escape of fluid must be avoided, through fear of prolapse of the iris, and of injurious shock, which results from too sudden diminution of the intra-ocular tension. This may be done by introducing the blade of the broad needle or iridectomy knife nearly vertically until the anterior chamber is entered, when it is turned to a horizontal position.

SAEMISCH'S OPERATION.

Saemisch's operation for indolent ulcer (Saemisch, Bonn, nineteenth century) consists in passing the point of a narrow-bladed cataract knife through the healthy portion of the cornea, 1 millimeter from one edge of the ulcer and bringing it out the same distance from the opposite edge; the knife is then made to cut its way out through the bottom

of the ulcer. The incision may be kept open by passing a fine probe through it every day or two, and the ocular tension kept down until the process of repair begins. This operation is also performed for corneal *abscess*.

TREPHINING OF THE CORNEA.

This operation (Bowman, London, 1872) is done by an instrument specially designed for the purpose. A circular disc of corneal tissue is removed, Descemet's membrane being generally left behind if possible. This operation is but little practiced in this country now.

IRIDECTOMY.

(Gr. ἰρις, and εκτομη, cutting out.)

The iridectomy knife (Wenzel, 1780) is entered through the cornea near its edge; carried on until the incision is of desired length; the point of the knife kept well toward the cornea so as not to wound the lens, and then withdrawn. The iris forceps are then passed through the incision, the iris grasped and drawn out, when the desired portion is cut off with scissors close to the lips of the wound.

IRIDOTOMY OR IRITOMY.

(Gr. ἰρις, and τομη, section.)

This is chiefly performed (Cheselden, England, 1782) where the iris has formed adhesions to the cornea or the lens, and where the pupil is closed by inflammatory deposits. The object of the operation is to make a slit in the iris, with the hope that its edges will retract, leaving a permanent

opening to serve as a new pupil. Sometimes the slit is made simply by a knife passed through the cornea and iris. Special instruments have been devised for the operation, such as the scissors of M. de Wecker (Paris, nineteenth century). The best knife for this purpose is one devised by Dr. F. W. Wilson (Bridgeport, Conn.), which is a very narrow and short cataract knife shaped like the Graefe knife. It is about 2 millimeters wide by 12 millimeters long.

CORELYSIS.

(Gr. κορη, pupil, and λισις, loosing.)

This is performed (Wenzel) to break up adhesions which have formed between the iris and the capsule of the lens. An opening is made near the corneal margin, a little to one side of the adhesion which it is purposed to loosen. A blunt, flattened hook is then passed in and made to tear through the attachment (Streatfield's method). Or, an incision having been made near the edge of the cornea, the iris is grasped by a pair of curved forceps, near the adhesion, which is then loosened by traction made toward the periphery (Passavant's method).

CATARACT OPERATIONS.

Keratonyxis (Gr. κερας, cornea, and νυσσω, to puncture), *Discission, or Solution of Cataract* (Conradi, Germany, 1797).—It is applicable only to soft cataracts. This operation consists in lacerating the anterior capsule by a fine needle passed in through the peripheral portion of the cornea. The aqueous humor thus comes in contact with the lens matter and softens it so that it is gradually absorbed.

The operation generally must be repeated several times. It is best to lacerate the capsule and lens very slightly, especially at the first sitting, else great swelling of the lens matter may result, causing injurious pressure. The pupil should be dilated well with atropin before the operation.

LINEAR EXTRACTION.

Soft cataracts are also removed through a *linear incision* made with a lance-shaped knife at the edge of the cornea; the lens matter may escape spontaneously as soon as the wound is completed, or require to be *coaxed out,* in the same manner as with hard cataracts, or to be removed by a Daviel spoon. When there is great swelling of the lens after keratonyxis, it should be evacuated at once through a linear incision. Soft cataracts are sometimes evacuated by *suction.* A suction instrument has been devised for this purpose, which can be passed through a small opening in the cornea.

EXTRACTION OF CATARACT.

This operation is designed for the removal of hard cataracts. It has completely supplanted the old and dangerous operation of *reclination,* or *couching,* by which the lens was pushed down into the vitreous humor and left there. The chief credit for introducing extraction is given to Jacques Daviel (France, 1745), although perhaps others had performed the operation before.

FLAP EXTRACTION OR SIMPLE EXTRACTION.

This is performed by a section made upward at the margin of the cornea, so that little less than half the cornea is comprised in the flap. It is important to make a suf-

ficiently large incision, so that the lens may easily escape. Thorough antisepsis has diminished or removed the dangers of a large flap. Preliminary to the operation for extraction of cataract—say, twenty-four hours before—the eyelashes should be washed with a solution of soda bicarbonate and an application of biniodid of mercury, 1 to 4000, made, after which a monocular bandage is applied, which should not be removed until the moment before the operation is to be performed. Then the conjunctival sac should be thoroughly irrigated with a saturated solution of boric acid, when the application of the anesthetic (cocain) is begun (Panas, Paris, 1894). Many operators prefer not to have the eye bandaged before the operation, as above described, but simply kept clean with boric acid solution.

The capsule is next opened by a cystitome. Then gentle pressure is made with a shell spoon on the globe of the eye just above the wound, and counterpressure with another shell spoon on the lower part of the cornea. In this way the upper edge of the lens is brought into the wound, when by making pressure upward with the lower spoon the lens is forced out of the eye. Great care should be taken in the "toilet" of the wound after the lens is delivered. With a flat iris replacer the iris should be pushed back into the anterior chamber, if hanging out of the wound or included in the wound. Oval pieces of gauze and cotton held on both eyes by adhesive strips, over which a bandage is applied, is the best dressing. The adhesive strips may be omitted in a quiet patient.

Graefe's Modified Linear Extraction (Albrecht von Graefe, Berlin, 1870).—The incision is smaller than in the flap operation, and may be regulated by the size and hard-

ness of the lens. The operation is usually performed somewhat as follows: The point of a narrow-bladed knife (a Graefe knife) is passed through the sclera just behind the edge of the cornea, and a little above its center, carried across the anterior chamber and out at a corresponding point on the opposite side. The first puncture is made with the point of the knife directed downward toward the center of the pupil, so that the inner lip of the wound may be as large as possible. After completing the puncture and counterpuncture, the edge of the knife is turned obliquely upward and forward, and, by a sawing motion, made to cut its way out, emerging about at the upper sclero-corneal margin. A piece of iris is next drawn out and exercised. The capsule is divided by the cystitome, preferably by a T-shaped incision or by an incision along the periphery. The lens is tipped forward into the track of the wound, generally by pressure and counterpressure with shell spoons as in the single extraction; then, by gently sliding the lower spoon over the cornea, the lens is forced out. The "toilet" of the wound should be carefully looked after, that no part of the iris remains in it. The dressing is the same as in simple extraction. The incision is made upward. In exceptional cases the incision may be made downward.

Liebreich's Operation (Liebreich, London, nineteenth century).—The incision is made with the narrow-bladed knife, is more transverse than in Graefe's operation, lying wholly in the cornea, except the puncture and counterpuncture, which are made in the sclerotic about 1 millimeter from its edge. No iridectomy is performed.

Preliminary Iridectomy.—A cataract is sometimes divided between two operations. At the first an iridectomy is

performed; then, at some subsequent time, some days or weeks after, the lens is removed. This is called Jacobson's method (Jacobson, Königsberg, nineteenth century).

Extraction in the Capsule.—In certain forms of cataract the lens is extracted in its capsule by passing a wire loop or spoon behind it. This sometimes happens unintentionally immediately after the corneal section is made.

SECONDARY CATARACT.

Operations for *secondary cataracts* consist usually in making a small hole through the membrane by tearing it with needles (called a needling) or forceps, or by cutting it with a knife or a special form of scissors.

A miniature Graefe knife (Wilson, Bridgeport) is one of the best of the so-called knife needles for dividing a membrane forming after the removal of the lens. Other knives are Galezowski's (Paris) and Knapp's and Weeks's (New York).

The membrane that usually exists should be operated upon if the vision is not satisfactory some months after the extraction of the cataract. With $V = \frac{20}{50}$ the patient will be able to read the finest print, and the operation will not be necessary. When the healing process has been without inflammation—no iritis has resulted, instead of dividing the capsule it is better to remove it or to cut out a portion of it if complete removal cannot be accomplished. For this purpose an incision is made in the cornea in the line of the incision for the cataract extraction, the capsule grasped by peculiarly constructed forceps, and, being pulled out, is cut off with scissors (Panas, Paris). Or a pair of Wecker's scissors may be introduced into the anterior chamber

through the incision in the cornea, and the membrane cut across, one blade of the scissors being pushed through the membrane before the cut is made.

During all operations involving a corneal incision the iris may fall forward into the wound, and if it cannot be replaced the prolapsed part must be snipped off with the scissors. It is a cardinal rule never to leave any iris entangled in the lips of an incision. After escape of a cataract a few drops of vitreous may follow, but if the eye is closed and bandaged at once, recovery may occur without bad consequences. Loss of vitreous is to be regarded as an unfavorable occurrence. It is apt to be attended by detachment of the retina and by intra-ocular hemorrhage.

In the judgment of the authors of this manual the best operation for senile cataract is simple extraction—that is to say, removal of the lens after a section with a Graefe knife without iridectomy. If in the course of the operation in spite of efforts to avoid this accident the iris is cut or if it prolapses, it may be cut off without impairing the success of the operation. After an operation is completed the patient may lie in a light room, but a black mask (Ring, F. W., New York) should be put on over the bandage, both for safety to the eye and exclusion of light.

STRABISMUS OPERATION (TENOTOMY, STRABOTOMY).[1]

A fold of conjunctiva and subconjunctival tissue is seized by the forceps near the margin of the cornea and over the insertion of the tendon to be divided. This fold is snipped by blunt-pointed scissors, curved on the flat, which

[1] Dieffenbach, Germany, 1839.

are then passed into the opening by a burrowing motion, and made thoroughly to divide the subconjunctival tissue about the insertion of the muscle. The strabismus hook is then inserted and passed under the tendon so as to catch it up, after which it is brought into view by pushing aside the conjunctiva. While held on the hook, it is divided by scissors close to its insertion. Another hook is then inserted and moved freely around, and any remaining fibers are caught up and divided in same way.

THE PANAS OPERATION FOR STRABISMUS.—Since its introduction by Panas, in 1900, a new method of operation has been performed by several surgeons in this country and is warmly recommended by them (Roosa, Davis, Peck). This operation is always performed on both eyes at one sitting, usually under a general anesthetic. In convergent strabismus both of the internal recti muscles are divided; in divergent strabismus both of the external recti. The muscle is taken up as has just been described and then stretched, if the internal rectus be the muscle operated upon, so that the cornea is buried in the outer canthus. After this stretching it is divided in the usual way. A suture is applied to the conjunctiva, but only one turn need be made in the thread. This is done in order to avoid cutting a knot, which, in the case of children, seems to them, even with the use of cocain, as a repetition of the operation. A bandage should then be applied for about twenty-four hours after the operation.

THE ADVANCEMENT OF THE INSERTION OF A MUSCLE.

An incision is made in the conjunctiva 1 to 2 millimeters from the edge of the cornea, circling the cornea for

the distance of 8 or 10 millimeters forward of the insertion of the muscle to be advanced. The conjunctiva and Tenon's capsule is dissected up with scissors from the sclerotic backward along the muscle and above and below it for the distance of half an inch. A tenotomy hook is then placed under the tendon of the muscle, lifted slightly from the eyeball, and three sutures (on three separate needles) are inserted through it from *without inward,* the conjunctiva and Tenon's capsule being included. One suture is placed through the center of the tendon, one through the upper third, and one through the lower third. The tendon is now cut with scissors close to the sclera, being careful not to cut the thread. The needles, which have been left on the threads, are taken in turn, the center one first, and a short, deep "bite" into the sclera (in a vertical direction, if one of the lateral muscles is being advanced; in a horizontal direction if the superior or inferior rectus) directly forward of the center of the former attachment of the tendon and 2 millimeters from the edge of the cornea, just where the first incision in the conjunctiva was made. The needle in the upper third of the tendon is then introduced in an oblique direction into the sclera, at a point directly above the middle suture and about 3 millimeters distant from it, and carried up and in (assuming the external rectus muscle the one being operated upon) for a distance of 3 or 4 millimeters before bringing it out through the conjunctiva. The lower suture is introduced at a corresponding point below the cornea in an oblique direction down and inward. The central suture is now tied; then the upper and lower sutures are tied at the same time (one by an assistant) so as to prevent torsion of the eyeball. The tendon of the opposing muscle should be cut if permanent effect is to be secured.

The above operation is called the "straight advancement," and is the simplest and easiest to perform of any of the advancement operations.

A hook armed with a thread is sometimes placed around the muscle to be advanced; this being tied, the tendon is cut and the sutures are inserted and tied as in the straight advancement (Agnew). Instead of advancing the muscle some operators make a knuckle in the tendon (Savage, Valk).

BOWMAN'S OPERATION FOR LACRYMAL DISEASE.

Bowman's operation for opening the canaliculi (Bowman, London, nineteenth century) is performed as follows: A fine director is passed into the puncture and along the canaliculus into the sac, its groove turned toward the free margin of the lid, which is kept tense by being pulled outward with the finger. The point of a narrow-bladed probe-pointed knife is inserted into the punctum, vertically, at first, then turned in the horizontal direction, the cutting edge turned upward and slightly backward, so as to cut in the mucous surface, and passed along the canaliculus into the lacrymal sac. When this is reached great pains should be taken to divide the tissues thoroughly down and *into the lacrymal sac.* A failure to do this makes the subsequent probing into the nasal duct very difficult or even impossible. Sometimes the knife is passed onward through the nasal duct for the purpose of dividing strictures.

Probing the nasal duct is done by Bowman's probes, which are of different sizes and bent to correspond with the course of the duct. The edge of the lid is kept on the stretch as before. The end of the probe is passed along the

divided canaliculus until it is felt to strike the hard inner wall of the sac. It is then raised into a vertical position with the convexity of its bend backward, and passed downward through the sac, and then downward, outward, and forward through the duct into the nose. When the end of the probe is *not in the sac,* each movement of it will be seen to cause a movement of overlying skin, and it will not give to the finger the sensation of striking against the firm bony wall as it does when in the proper position. The original size of Bowman's probes have been of late greatly increased. In appropriate cases numbers running much higher than the original series are used. (Theobald, Baltimore.)

The exact manner of passing lacrymal probes to be used in individual cases, the amount of force to be used, and so forth, can only be learned by experience. When a lacrymal abscess has formed, and it cannot be readily evacuated by an opening through the canaliculus into the sac, an external incision, free and deep, should be made. No fear need be had lest a scar be permanent if after the evacuation of the abscess externally an opening is made through the canaliculus and the nasal duct probed in the usual way. In very bad cases of lacrymal abscess with disease of the bone, destruction of the lacrymal sac, and persistent lacrymation it is wise to destroy the mucous lining of the sac with caustic after freely laying it open. In this latter and many other lacrymal operations it is proper to use a general anesthetic.

CANTHOPLASTY: DIVISION OF THE OUTER CANTHUS.

Pass one blade of strong scissors behind the commissure to the bottom of the *cul-de-sac,* and the other in front, and divide the commissure by one sharp cut, the in-

cision being exactly horizontal. The conjunctival surfaces of the wound are then joined to the cut edges of the skin by three or four fine sutures, one below, one above, and one at the outer angle being usually sufficient. After making the first incision some recommend to put the upper lid on the stretch by pulling it toward the nose, and to divide the upper canthal ligament by a nick with the scissors, at right angles to the first incision, the nick being made about two lines from the temporal border of the orbit (Agnew, New York). A simple incision of the canthus without sutures is more properly called *canthotomy.*

THE OPERATION FOR ENTROPION.

The most common one is the Jaesche-Arlt operation or a modification of it. A horn spatula is placed under the upper lid, and, by traction on the skin, the edge of the lid is rolled upward and outward. An incision is made along the edge of the lid, from near the *punctum lacrymale* to the outer angle, dividing it into two layers, the outer containing the cilia and their bulbs, the inner the conjunctiva and cartilage. The incision is about $^1/_{10}$ inch deep. A strip of skin, somewhat oval in shape, is then excised from just above the margin of the lid and running its whole length. The edges of the wound are united by sutures, and this rolls the anterior lip of the split border, containing the eyelashes, outward. Sometimes a strip of orbicularis muscle and a wedge-shaped piece of the cartilage are excised with the fold of skin. The bridge of skin containing the lashes is sometimes separated from the underlying tissue, so that it can be moved upward and so transplanted to a higher point

as the edges of the wound in the integument are drawn together. A canthoplasty is often done also. Other operations are also done for this deformity.

The operations for *ectropion* are numerous, and vary with the special requirements of the case.

The latest modifications of the Jaesche-Arlt operation consist essentially of:—

First, evert the lid and make incision in the mucous surface 2 millimeters from the edge of the lid and extending the entire length of the lid, down to and through the cartilage. The lid is then turned back to the natural position, a horn spatula inserted under it, and an incision 4 millimeters from the edge of the lid in a horizontal direction, entirely across the lid, is made through the skin and muscle down to the cartilage. The incision on the outside of the lid is purposely made higher than the one on the inside, so as not to scalp the lid. The orbicularis muscle and skin is dissected from the cartilage to its upper edge, and some operators cut away an elliptical piece of this freed skin and muscle. Four deep sutures are then inserted. The needle is inserted into the narrow strip of skin left just above the eyelashes, brought out and then dipped into the upper edge of the cartilage and then through the skin at the upper edge of the wound. Four such sutures are taken and then tied over a probe so as to roll the inverted lashes outward, the probe being withdrawn as each suture is tied. Four or five sutures may be taken in the skin to close the wound neatly and closely. (John Green, St. Louis; Hotz, Chicago.)

ENUCLEATION OR EXCISION OF THE EYEBALL.[1]

The patient being under a general anesthetic, the conjunctiva is seized with forceps and divided all around the cornea quite close to its edge, by a circular incision, with blunt-pointed scissors curved on the flat. The tendons of the muscles are picked up successively by a strabismus hook and divided close to the sclerotic. The eyeball is then drawn over to one side by forceps, and scissors (with curve toward the eyeball) are passed back along its surface to the optic nerve. The blades are then opened and made to divide the nerve close to the sclerotic. Usually the hemorrhage is slight, and is easily controlled by pressing a sponge for a short time upon the bleeding points. When it has ceased the orbit is packed with gauze loosely, the lids are closed, and a bandage is applied. By this operation the orbital tissue and muscles are left behind to form a good, movable stump for the artificial eye. In certain conditions, as of malignant disease, a considerable piece of the optic nerve is sometimes excised with the eyeball. Some use a suture to close the conjunctiva (Argyll Robertson).

Artificial eyes may be worn after the wound has cicatrized and all irritation ceased. It is best to begin to fit them a few days after the enucleation, so as to prevent contraction of the orbital cavity and to give it a good shape. They should be worn at short intervals at first until the parts become accustomed to the presence of the foreign body. If *sympathetic trouble has existed in the other eye,* extra caution should be taken lest the artificial eye be worn too soon.

---

[1] Bonnet, France, 1841.

They must not be worn too long without renewal, as they become rough and irritating. They sometimes give rise to severe conjunctivitis of the stump, and sometimes to sympathetic irritation of the other eye.

Shells are made to wear over shrunken eyeballs where no enucleation is performed. As a general rule, it is better to remove such shriveled stumps; but if absolutely no irritation is caused by them, enucleation need not be performed, although it is then justifiable if an artificial eye cannot be worn over the stump.

The carelessness of patients in not maintaining an aseptic condition of the stump after removal of the eyeball is at the basis of some of the cases of conjunctivitis arising from the use of an artificial eye. They should be instructed to keep the eyes clean with a saturated solution of boric acid and to use an astringent—say, of alum sulphate, gr. iij to ℥j, or the like—if catarrh of the conjunctiva occurs.

Snellen's Artificial Eyes.—The best of the artificial eyes are those suggested by Snellen, which are made much thicker by virtue of being hollow inside the two surfaces, than the ordinary so-called shells until lately universally used.

Some operations not described in this chapter will be found under their appropriate headings in other parts of the book.

The After-treatment.

The after-treatment of operations requires special attention and study. After the principal operations upon the eyeball, it may be advisable to use atropin or eserin, according to indications; to apply a compress bandage over both eyes, and to keep the patient in bed, with more or less seclusion from the light. When desirable to keep the eye closed

for several days, the surgeon can judge of its condition, to a certain extent, from the appearance of the lids. If the lids are red, swollen, and edematous, this may be regarded as an unfavorable indication regarding the parts beneath. A purulent discharge is also a bad sign. If severe inflammatory reaction occurs, antiphlogistic treatment by leeches, fomentations, or iced cloths is employed. The operations on the lids and the muscles require a bandage for from twenty-four to forty-eight hours, and nothing more, as a rule.

Cocain ranks, perhaps, next to atropin in subduing the pain from iritis and keratitis, traumatic or idiopathic, and is often used in combination with the latter.

Antiseptic precautions—before, during, and after operations—have, since Lister's discoveries (Edinburgh, 1865), assumed their proper importance. Many surgeons, after cleansing all their instruments, dip them in a carbolic acid solution; wash the eye with bichlorid solutions, 1-5000 to 1-20,000, and wash their own hands, after cleansing with bichlorid solutions. Too much care cannot be taken in cleansing the hands, finger-nails, and instruments of the surgeon, as well as the field of operation. Great care should be taken to see that the teeth of the forceps are absolutely clean. But no local antiseptic precautions will avail in some cases of general disturbance of the nutrition, or where chemical and mechanical violence comes in to destroy the effect of the most cleanly operation. The general hygiene of a hospital or dwelling where operations are performed should be scrupulously regulated.

The authors of this volume sterilize their instruments in steam. Great care should be taken to use only sterilized

solutions, droppers, and gauze in all eye operations. Sterilized water and sterilized instruments, sterilized hands of the operator, and sterilized dressings, have finally been accepted as all the precautions necessary for operations upon the eye.

CHAPTER III.

DISEASES OF THE EYE.

THE ORBIT.

THE ORBIT has close relations, through its membranes and vessels, with the nose, antrum, cranial cavity, and temporal fossa. Its diseases, therefore, are not always independent. They are not usually limited to a single tissue, but so classified for convenience. The symptom common to many orbital diseases is *exophthalmos*, or *protrusion of the eyeball.* It may be hardly perceptible, or so severe that the lids cannot close, and the exposed cornea sloughs and allows the contents of the eye to escape. *Rarely* the globe may be forced entirely out and lie upon the cheek. With protrusion there is redness and edematous swelling of lids and conjunctiva (chemosis), the mobility of the globe is impaired, and the nerves may be paralyzed from pressure. Vision is impaired according to the tension and pressure upon the optic nerve and the ocular tunics. Thrombus of the retinal vessels may be caused by orbital cellulitis, and the sight destroyed in that way.

INJURIES.—These are generally due to incised or punctured wounds or to foreign bodies. They may cause orbital abscess, periostitis, hemorrhage, emphysema, fracture of the bony walls, injury of the eyeball, and even extrusion of it. The results may appear at once, or *not until some time after the accident.* Fractures of the roof and inner wall are very dangerous from injury to the brain, while fractures at the apex of the orbit often cause optic atrophy by pressure, and

consequent blindness. Foreign bodies should always be removed if detected. The best place for incision, either for exploration or removal, is through the conjunctiva between the eyeball and the lid. The outer canthus may be divided to give more room for manipulation. The parts should be kept at rest, and cold and leeches used to check inflammation. If the eye is extruded, it may be replaced and a compress bandage applied. Incised and punctured wounds are treated as in other parts.

PRESSURE UPON THE ORBIT, with a tumor at the upper inner angle, and displacement of the eye downward and outward, is sometimes caused by distension of the frontal sinus. The tumor, if left to itself, may burst into the nose, orbit, or through the upper lid.

EMPHYSEMA.—This usually results from fracture of the ethmoid cells or frontal sinus, or rupture of the lacrymal sac. Air enters the cellular tissue of the orbit and lids, causing elastic, crepitating swelling, and exophthalmos. It generally disappears under gentle pressure.

HEMORRHAGES.—These are chiefly from injury, sometimes spontaneous, or are due to straining. Ecchymosis may appear in the lids and under the conjunctiva some time after the accident. They may cause exophthalmos and injurious pressure. The best treatment is to assist absorption by cold compresses and firm bandage. Incisions may be made where the symptoms are urgent.

ABSCESS: ORBITAL CELLULITIS.—This is caused by wounds; foreign bodies; disease of bone; cold; lacrymal disease; operations on the eye; extension of inflammation from other parts, especially the neighboring sinuses; severe constitutional disease, as erysipelas or typhus fever. The

symptoms are almost always acute, reaching a crisis in from four to ten days. The lids are red, hot, and swollen; intense pain, increased by pressure against the globe; fever, and perhaps cerebral symptoms may be present. There is exophthalmos, generally directly forward. Sight may be impaired from pressure on the optic nerve, which may cause engorgement and neuritis. When pus forms, fluctuations may be found behind the lids, and the abscess may burst through the lids or the conjunctiva. The prognosis should be guarded, on account of possible necrosis, meningitis, and permanent injury of vision. Antiphlogistics in the early stages; if suppuration occurs, poultices, and incision through conjunctiva between the lids and the globe, should be employed. An exploratory incision is proper when in doubt about pus, and it is always better to use the knife too early than too late.

INFLAMMATION OF TENON'S CAPSULE occurs very rarely. It is caused by neglect of proper aseptic precautions and ophthalmitis. It produces pain, swelling, and redness of the conjunctiva and, to a less extent, of the lids, with perhaps slight exophthalmos. Leeches and ice compresses may be used in the early stages.

PERIOSTITIS.—This is generally limited, and due to cold, injury, foreign bodies, or is secondary to inflammation of other parts. In the *acute* form there is severe pain and *local tenderness on pressure against the bony wall.* There are swelling and redness of the lids and perhaps slight exophthalmos—generally toward one side. Sometimes fever occurs. Pus may form beneath the periosteum, and necrosis may result. The general treatment is that of cellulitis. In the *chronic* form, which is generally due to syphilis, symptoms are less marked. The pain is apt to be worse at night.

Nodes and exostoses may develop. Treatment should be that for syphilis.

CARIES and NECROSIS result from injury, periostitis, cellulitis, syphilis, and tuberculous and scrofulous cachexiæ. They cause sluggish, edematous, inflammatory swelling of the lids, which points and discharges foul pus. A fistulous opening is indicated by unhealthy granulations, and dead bone may be felt by the probe. The pus should be evacuated as soon as possible, and an opening enlarged, when necessary, for removal or escape of exfoliated bone. The sinus should be kept open and clean until it can heal from the bottom. In the healing process there is apt to be cicatricial contraction of the lid, leaving severe ectropion.

TRUE ANEURISM may arise from the ophthalmic artery or its branches, causing protrusion and pulsation of the globe. The pain is generally slight.

DIFFUSE, OR FALSE, ANEURISM is much more frequent. It is caused by rupture of the artery from injury or disease, with sudden escape of blood into the orbital tissue. It may supervene upon true aneurism. There is immediate pain and exophthalmos. The latter increases, with redness and swelling of the globe and the lids; and an elastic, pulsating tumor appears at the edge of the orbit. The pulsation is stopped by pressure on the carotid. There is a whirring noise in the head, audible with or without the stethoscope. The only treatment for true or false aneurisms is by compression or ligature of the carotid.

ANEURISM BY ANASTOMOSIS.—This is rare, and is generally congenital and found in children. It is most often situated in the subcutaneous tissue of the anterior part of the orbit. It consists of groups of dilated vessels forming

an irregular, doughy tumor with pulsation and thrill, and is not much affected by pressure on the carotid. The best treatment is by subcutaneous ligature or electrolysis.

Tumors of the orbit are of the same kind—benign and malignant—as are found in other parts of the body. They may arise in the orbit or invade it from the eyeball or from neighboring parts. They cause exophthalmos and its injurious consequences. Malignant tumors are of more rapid growth than benign ones, and involve the general health. Tumors should be excised when there is any prospect of benefit from operation—if possible, without sacrificing the eyeball. It is often necessary, however, to remove the latter also, even when considerable vision remains to it.

Exophthalmic Goiter.—This, a form of exophthalmos of both eyes, without much loss of vision, associated with cardiac disturbance and enlargement of the thyroid gland, occurs in *Basedow's* or *Graves's disease,* and is termed *exophthalmic goiter.* There is a peculiar staring appearance of the eyes, and the upper lid does not follow the globe normally in the downward movements of the latter. The exophthalmos sometimes disappears or becomes less marked after appropriate general treatment directed to the cardiac disease.

The Conjunctiva.

Foreign bodies upon the conjunctiva cause marked irritation, congestion, and lacrymation or flow of tears (Lat. *lachryma,* tear), together with spasmodic closure of the lids, pain, and *gritty* sensations. They may be washed away by the free flow of tears excited, or, if not thus acted upon, may require removal. The ocular and palpebral conjunctiva

must be thoroughly exposed and examined by the aid of a good light and a magnifying glass. If a foreign body be upon the palpebral conjunctiva, it is easily removed by a bit of soft cloth; or, if deeply imbedded, by spud, needle, or forceps, cocain having first been instilled until the conjunctiva is thoroughly anesthetic.

Sand, bits of broken glass, and so forth may be washed away by a stream of lukewarm water. *The sensation of a foreign body may persist for some time after its removal,* although usually perfect relief follows.

Injuries from lime, mortar, acids, hot fluids, etc., cause excoriation, sloughing, and—in healing—cicatricial contractions. The eyes should be carefully washed with warm water except in case of lime, when the lime should be wiped away with cotton moistened in oil or vaselin, and soothing applications made, olive-oil being a very useful one. Cocain is required both for the removal and for unpleasant sensations that may remain. If the patient is seen at once, lime may be neutralized by vinegar and water (ʒj to ℥j) or a solution of cane-sugar (ʒj to ℥iij) or molasses; acids by solution of soda (ʒj to ℥iv). The after-effects should be treated as the indications call for. Astringents are to be avoided where excoriations exist. Atropin is nearly always useful.

Ecchymosis.—This occurs from rupture of the vessels by injury or violent exertion, such as sneezing or coughing; during scurvy and Bright's disease; in the course of inflammations; without any apparent cause; or may extend forward from the orbit—usually some time after the accident. Treatment by hot water or slightly stimulating lotion (tincturæ arnicæ, ʒj to aquæ ℥iv).

EDEMA OF THE LID.—This is frequent in inflammation; occurs spontaneously in debility, old age, and kidney disease. A compress bandage and mild astringent wash are sometimes employed.

EMPHYSEMA occurs, rarely, from fracture of the nose or rupture of the lacrymal sac, and causes crepitating swelling. A pressure bandage affords relief.

CONJUNCTIVITIS.

Inflammation of the conjunctiva may be divided for convenience of description into the following varieties:—

1. *Catarrhal.*
2. *Purulent.*
3. *Diphtheritic.*
4. *Granular.*
5. *Phlyctenular.*

The classification is arbitrary; one form may run into another; and a discharge from one form may reproduce that form or a different one. All these are contagious and infectious, and may occur epidemically except the phlyctenular. So-called "pink eye" is but an epidemic catarrhal conjunctivitis. A differential diagnosis is sometimes impossible at first.

CATARRHAL CONJUNCTIVITIS: CATARRHAL OPHTHALMIA.

This is the mildest form of conjunctival inflammation. It is caused by injuries, exposure, bad hygiene, exanthematous diseases, and so forth; or may be secondary to other inflammations. In rare cases it is due to errors of refraction. In the epidemic forms of "pink eye" the Koch-Weeks bacillus is found.

Symptoms.—Smarting, itching sensation as of sand in the eye; lacrymation; increased vascularity, causing partial or uniform redness of the globe and giving to the inner surface of the lids a rough, velvety appearance; chemotic swelling of the membrane and subjacent tissue, the *chemosis* (Gr. χημη, a gaping?), if severe, may rise above the level of the cornea, causing it to appear sunken; redness, swelling and stiffness of the lids; mucous or muco-purulent discharge, with tendency to gluing together of lids, especially in the morning. Usually it attacks both eyes at once. It is amenable to treatment, and is not very apt to invade the cornea. The microscope usually will detect the bacillus at an early stage.

Treatment.—In this (and in all other forms) extreme cleanliness as regards the patient, and all towels, utensils, used by him, with isolation if necessary; hygienic precautions must be taken and attention to the general health must be given. Locally, a mild astringent lotion every few hours; a nitrate of silver solution, gr. x-xv to ℥j, if applied within a few hours of the first symptoms, will materially shorten the attack, or argyrol in 30- to 50-per-cent. solution may be used. Cold applications should be used at an early stage. Catarrhal conjunctivitis is, however, a self-limited disease, which often requires very little local treatment except cool applications, and which, with aseptic cleaning, good hygiene, runs its course and terminates in complete recovery in a few days.

Patients with an acute catarrhal conjunctivitis should not usually be confined to the house, but with protection glasses (Coquilles) may be out in mild weather for exercise and air.

BLENNORRHEA.

This form of conjunctivitis may be defined as a mixed case of catarrhal and purulent inflammation, the purulent element predominating in the secretion, but not being completely purulent, and yet it is perhaps an arbitrary distinction to make a subdivision between catarrh and blennorrhea.

PURULENT CONJUNCTIVITIS: EGYPTIAN, CONTAGIOUS, OR MILITARY OPHTHALMIA.

This form is like the last variety, with all the symptoms intensified, and is due to the same causes. It often appears as an epidemic in workhouses, barracks, etc., where people are crowded together. The discharge is purulent, thick, and very contagious. There is great danger of invading the cornea, causing ulceration, sloughing, and perhaps loss of the eye in a short time. The gonococcus is the bacillus that is the origin of the disease.

Treatment.—Mild cases should be treated much as the catarrhal form. Severe ones usually require isolation, darkened room, and rest in bed. *Pus should not be allowed to accumulate* in the eyes. Sometimes cleansing is needed every few minutes, day and night. Cold applications, leeches, scarification of the conjunctiva if there are great swelling and chemosis, canthotomy, if the lids press greatly upon the globe, are the measures to be used. When a discharge appears, an astringent lotion should be applied every few hours, and some caustic application, such as nitrate of silver solution, gr. x-xx to ℥j, to the inner surface of the lids *once a day.* Cold compresses should be continued, or changed for hot ones if more agreeable to the patient. Atropin is

to be used if the cornea becomes involved. If only one eye is affected, the other may be closed by a glass watch-crystal fastened over the eye with adhesive plaster (F. Buller, Montreal). When the case is seen *at the very outset,* thorough cleansing and a caustic application of silver nitrate gr. xxx to ℥j, to the inner surface of the lids sometimes seem to shorten or may even abort the attack.

GONORRHEAL CONJUNCTIVITIS: GONORRHEAL OPHTHALMIA.

This disease does not differ, except in manner of origin, from any other purulent conjunctivitis. It is an extremely virulent, purulent inflammation, caused usually by inoculation from a urethral discharge. It may destroy the eye in a few days. The finding of the gonococcus germ is the crucial test for the existence of contagious conjunctivitis of this form. The treatment is the same as in purulent conjunctivitis.

CONJUNCTIVITIS IN THE NEWLY BORN: OPHTHALMIA NEONATORUM.

(Gr. *νέος*, new, and Lat. *natus*, born.)

Catarrhal or purulent conjunctivitis of infants, usually appearing shortly after birth, is caused by contact with vaginal discharges of the mother, or with linen soiled by her vaginal discharges. An instillation of a 2-per-cent. solution of silver nitrate in the eyes of the newly born is likely to prevent contagion, even when the mother is affected with purulent inflammation or blennorrhea of the genitals. Careful cleansing of the eyes should precede the instillation (Credé, nineteenth century); when it is certain that the

mother's genitals are in a healthy state, Credé's method, which has some dangers of excessive reaction, should not be used, while in all cases a newly born infant's eyes are to be carefully observed, and kept clean with a saturated solution of boric acid or the like.

The *treatment* is the same as in similar inflammations of the adult, and is regulated by the severity of the attack. It is believed by many that, in infants, caustics are needless and injurious; and that a mild astringent application is sufficient, such as alum sulphate, gr. j to ℥j.

MEMBRANOUS CONJUNCTIVITIS.—This occurs in two forms—*diphtheritic* and *croupous.*

DIPHTHERITIC CONJUNCTIVITIS.

This occurs in the course of diphtheria. It begins with great heat, redness, swelling, and *tenderness* of the lids, with rigidity and stiffness *from fibrinous infiltration.* There is firm swelling of the conjunctiva from the same cause, and pale, smooth, glistening appearance of its surface. This condition is due to infiltration over the conjunctiva, and the infiltrate (not a true membrane) cannot be rubbed off, as it can be in the croupous form. The advanced stage is marked by softening of the parts, from disappearance of fibrinous matter, and by discharge of pus. There is great tendency to shrinking and cicatrices of the conjunctiva in healing. The cornea is apt to suffer. The constitutional disturbance is often marked. It is very destructive to the eyes. It is rare in the United States and England.

The *treatment* is not very effectual. Hot compresses, leeches, etc., should be used, in the first stage and astringents and caustics in the purulent stage. Atropin should be used throughout, together with support of the general system.

CROUPOUS CONJUNCTIVITIS.

This has many of the symptoms of the diphtheritic form, but they are less intense. The lids are not stiff and "leathery" as in the former, and the grayish membrane may be rubbed of, usually followed by some bleeding. There are no constitutional symptoms. It is not nearly so dangerous as the diphtheritic form. Removal of the membrane and cleanliness form the chief part of the treatment. Iced cloths may be applied in the very early stages, but hot applications must be used later, especially if the cornea becomes involved. Caustics should not be used until the late stages; then argyrol, 25 per cent., may be applied once a day.

Although the treatment of conjunctivitis has not been materially changed by our better knowledge of its etiology, very much more is known as to the reasons for the old-time management of conjunctivitis. Simple catarrhal conjunctivitis, although it may be excited by the various causes,—atmospheric conditions, wind, traumatisms, errors of refraction, naso-pharyngeal catarrh, and so forth,—really exists from the growth of a morbid bacillus, named the Koch-Weeks bacillus, because it was discovered by Koch, in Berlin, and Weeks, in New York, at the same time.

This bacillus, which has its own distinct type, may be found in cases of catarrhal conjunctivitis, and our remedies —nitrate of silver, argyrol, alum, and other astringents, act literally as germicides, and the approximate cause of the infection is due to direct impinging of the germ upon the conjunctiva under favorable conditions. However, we should look after the health of the patient, and great care should be exercised as to cleanliness. In spite of the discovery

of the bacillus, catarrhal conjunctivitis remains a self-limited disease, and often passes off, with no positive treatment except thorough local cleanliness, without doing any damage.

With purulent conjunctivitis the case is entirely different. Probably no case of purulent conjunctivitis arises unless the gonococcus bacillus is carried into the eye in one of the many ways that this would be possible—from the eyes of another person, from soiled linen, from dried secretions carried about in the dust and dirt.

In trachoma the bacillus of origin has not been discovered, so that we can add nothing to our knowledge of this disease beyond what was known before the acceptance of the germ theory in the origin of disease. In the conjunctiva, as in other parts of the human body, external conditions may enable one to throw off the active influence of the Koch-Weeks bacillus, for example; while it is very doubtful if any constitution could escape a thorough-going and possibly destructive infection, if the gonococcus enters the conjunctival sac.

TRACHOMA: GRANULAR CONJUNCTIVITIS: GRANULAR OPHTHALMIA: GRANULAR LIDS.

This is generally a result of one of the above described inflammations, and essentially a chronic condition, although sometimes associated with acute symptoms. The so-called granulations, or trachomatous bodies, are almost entirely confined to the palpebral conjunctiva, and are chiefly two kinds: (1) enlarged conjunctival papillæ; (2) "frog-spawn granulations," grayish bodies, looking like sago grains, and composed of lymphoid cells and connective tissue, for the most part confined to the *cul-de-sac*. Both varieties may be

seen separately, but more often mingled. The symptoms are those of annoying chronic conjunctivitis, more or less severe. If the process is not checked, the cornea falls into a state of ulceration and vascularity (pannus—Lat. *pannus,* a red cloth), from constant friction of the rough lids upon it; the conjunctiva and tissues of the lids may become atrophied and cicatricial, leading to entropion, symblepharon, xerophthalmia, and so on. The disease is often associated with poor general health and bad hygiene. It usually runs a tedious course.

Treatment.—Cases that do not promptly yield to caustic treatment, or perhaps many without regard to duration, can best be treated by a preliminary operation. This should be performed under ether. After exposing the conjunctiva the trachomatous bodies are squeezed with forceps especially adapted for this purpose, so that each individual trachomatous body is squeezed thoroughly. Ayres, Noyes, Knapp, and Prince have invented forceps adapted to this purpose. The eyes are then cleansed with boric acid solution and bandaged for twenty-four hours.

When the bandage is removed, a blunt-pointed probe should be carried the full length of the *cul-de-sac* above and below, to separate adhesions between the folds of conjunctiva and between the lids and the globe. This should be done daily for five or six days. On the second or third day a membrane forms on the lids, and this should be removed daily, for if not it becomes organized and forms scar-tissue, which we wish to avoid. The patient should be seen daily for a week, and thereafter for three or four weeks, to apply mild caustics to complete the cure.

The disease has become epidemic in the last few years in the public schools of New York, probably from contagion

from European immigrants coming from towns and villages in Finland, Roumania, and other countries, where the disease has been epidemic for decades. Great precautions are now taken by the United States authorities to prevent entrance of trachomatous patients into this country.

When an operation is not necessary the treatment is by astringents and caustics, sulphate-of-copper crystal being a favorite one. A solution of bichlorid of mercury, 1 to 500; nitrate of silver; alum, and many other remedies are in common use.

Before beginning any astringent treatment of an inveterate trachoma it will be often necessary to use hot water, atropin, and cocain until the great irritation and photophobia subside. Then we may begin with a mild astringent —alum, drops of tannin and glycerin, or the like. In very obstinate cases, with pannus as a complication, after a fair trial with other remedies, jequirity becomes a valuable and, if used under proper precautions, not a dangerous agent. Those precautions are: 1. Keep the patient in his room or ward during the treatment. 2. As soon as the membranous inflammation has appeared, stop the jequirity and use iced cloths until the reaction has abated. 3. Then treat the case as one of ordinary trachoma, when sulphate of copper may be used until the cure is complete.

PHLYCTENULAR CONJUNCTIVITIS.

Gr. φλύκταινα, blister.)

Characteristic of this form of conjunctivitis is a small, yellowish-red elevation, *nodule* or *phlyctenule,* on whose summit a serous vesicle forms, which bursts and leaves a small

ulcer. One or several of these bodies may be present; they are generally situated near the margin of the cornea, and run their course in eight or ten days. The conjunctival congestion may be general or partial—a triangular leash of vessels running up to each phlyctenule, its base pointing toward the retrotarsal fold. The appearance of phlyctenulæ is attended by burning pain; photophobia, or dread of light (Gr. φως, light, and φοβος, fear); and lacrymation. It is often associated with phlyctenular keratitis. Relapses are very common.

Treatment.—Particular attention must be given to the general health. The patient should be placed on a simple diet: milk, bread and butter, fresh meat once a day, and vegetables. No sweets allowed, and no tea or coffee. Tonics should be given, especially syrup of the iodid of iron, and codliver-oil. Locally, atropin, 1 or 2 grains to the ounce, and the application of a mild irritant, such as calomel, or yellow oxid of mercury ointment rubbed into the eye.

PTERYGIUM.

(Gr. πτερύνιον, a little wing.)

This is a quite common affection, which results from inflammation and from constant exposure, such as is experienced by sailors, residents in tropical climates, on the Western prairies, etc. It consists of hypertrophy of the conjunctiva and subconjunctival tissue, forming triangular, vascular prominence, generally at the nasal side of the eye, with the base toward the inner canthus, and the rounded apex at the edge of the cornea, or encroaching more or less upon the latter. It is called pterygium *tenuis* (Latin for *thin*) or *cras-*

sum (Latin for *thick*), according to its thickness. It requires no treatment unless it extends upon the cornea so as to obstruct vision. It may then be removed by: 1. *Excision:* performed by dissecting the growth off from the cornea and sclerotic to a point near the canthus, and uniting the conjunctival wound by sutures. 2. *Transplantation:* this is performed by dissecting it off up to the base, and then inserting it under the conjunctiva below, which has been dissected away from the eye down to the lower *cul-de-sac,* retaining it there by a suture through the tip of the pterygium. The original wound is closed by sutures in the conjunctiva. 3. *Ligature:* by a thread passed around the growth at two or more points, and tied, so as to cause strangulation. If preferable, a new pupil may be made by an iridectomy opposite the clear part of the cornea.

XEROPHTHALMIA, OR DRYNESS OF THE EYE.

(Gr. ξηρος, dry, and ὀφθαλμός, eye.)

This disease generally results from severe chronic conjunctivitis. The condition is one of atrophy and cicatricial change in the cornea and conjunctival tissue; the surface being of dirty greenish or grayish color and tendinous appearance; and dry, scaly, and stiff from destruction of the secreting apparatus. Obliteration of the palpebral folds occurs, and there is more or less adhesion of the lids to the globe.

Treatment is inefficient. It is an incurable disease. The dryness may be alleviated by a bland wash, such as milk or glycerin, and by applying oily instillations into the eye.

SYMBLEPHARON.

(Gr. συν, together, and βλεφαρον, eyelid.)

This is an adhesion between the conjunctiva of the lids and the globe. It results from injuries causing excoriation and sloughing, or from long-continued inflammation. The adhesion may be complete or only partial, in form of small bands or bridles. It is difficult of cure. Various operations are done, the aim being to separate the surfaces and to keep them from reuniting.

ANKYLOBLEPHARON.

(Gr αγκυλωσις, stiffening, and βλεφαρον, eyelid.)

This is an adhesion between the edges of the lids. It has the same causes as symblepharon, and is sometimes associated with it. One of the best methods is to dissect or cut the lids apart and then cover the surface removed with conjunctival flaps from the two sides of the eyeball.

TUMORS OF THE CONJUNCTIVA.

Pinguecula (Lat. *pinguis,* fat).—A small, yellowish tumor, of fatty appearance, situated near the corneal margin and chiefly seen in elderly people. It consists of hypertrophied conjunctiva and epithelium. It is harmless. It may be excised if desired.

Dermoid Tumors.—Smooth, yellowish tumors, covered with conjunctiva and perhaps short hairs. They are composed of connective tissue and fat, and are generally congenital. Excision is the proper treatment.

Warts, similar to those occurring on the prepuce, may occur on any part of the conjunctiva. They should be snipped off with scissors.

Malignant growths very rarely may be found on the conjunctiva.

The Cornea.

INJURIES AND WOUNDS.

They are of the most varied kinds. The primary treatment in all is to put the eye at rest and allay the irritation by soothing applications. Atropin and cocain should be applied several times daily, and cold compresses if there be severe reaction. Hot compresses are often more soothing than the cold, and are preferable in the later stages. Where the epithelium is abraded, a few drops of olive-oil is useful to lubricate the parts and allay pain. A compress bandage may be used to restrain motion of the lids and exclude the light. Beyond this the treatment must be adapted to special requirements of the case.

FOREIGN BODIES.

They are of very frequent occurrence, the most common being particles of metal, dust, glass, gunpowder, etc. They cause severe reaction according to the depth to which they penetrate and the time they are allowed to remain. (*Exceptionally,* a foreign body remains for an indefinite period, causing no disturbance.) They are generally easily seen by simple inspection or oblique illumination. If superficial they may be removed by a spud; if firmly imbedded, by a needle or fine forceps. When there is danger of a foreign body falling back into the anterior chamber during efforts at

removal, a broad needle or narrow cataract knife is sometimes passed into the chamber so as to press upon the foreign body from behind and support it as it is being extracted (Agnew, New York). While removing a foreign body the eyeball may be steadied as follows: Stand behind the patient, with his head against your chest; have him look downward, and press the tip of your forefinger against the sclerotic just above the cornea and the tip of the middle finger of the same hand against the sclerotic below and a little to the inner side of the cornea. In all ordinary cases no speculum or fixation forceps is needed.

If lacrymation be present or spasm of the orbicularis muscle, so that the patient cannot easily open the eye, a 4-per-cent. solution of cocain should be used to quiet the eye before searching for the foreign body. In any case it should be used, several drops being instilled before an instrument is employed for the removal of the foreign body.

HERPES ZOSTER OPHTHALMICUS, OR OPHTHALMIC HERPES.

This affects the skin supplied by the ophthalmic division of the fifth, or trigeminal, nerve—that is, the forehead, upper lid, and the side of the nose. It never crosses the median line. The eruption of herpetic vesicles is generally attended with pain. There may be corneal ulceration and iritis, with photophobia and lacrymation. It is most frequent in old people. Cold is a common exciting cause. The disease is usually obstinate. It may leave deep scars, severe neuralgia, and anesthesia of the skin and cornea. Treatment is not very satisfactory. It comprises atropin, evaporating lotions, tonics, etc.

INJURIES FROM CHEMICAL AGENTS, BURNS, ETC.

These are apt to cause sloughing and permanent opacities and are to be treated as similar injuries of the conjunctiva.

ABRASION OF THE EPITHELIUM.

This is readily seen as roughened, glistening facet and is very painful. A frequent cause is a scratch from the finger-nail of a child in the lap of its mother.

WOUNDS.

They are chiefly dangerous from injury to the deeper parts, which may fall forward *(prolapse)* into the wound or escape altogether. Contused wounds are apt to cause suppuration. Incised wounds, if not infected, generally heal readily.

Great care should be taken to cleanse the eye with sterilized water and to continue to keep it in an aseptic condition after an injury.

KERATITIS: INFLAMMATION OF THE CORNEA.

(Gr. κερας, cornea.)

This results from injuries, exposure, constitutional disease, malnutrition, inflammation of adjacent parts. It may involve a part or the whole of the membrane. It leads to vascularization, cell proliferation, and suppuration, each of these phenomena being more or less prominent according to the kind of inflammation present. It is attended by impaired vision, ciliary irritation, a zone of fine vessels around the corneal margin, pain, photophobia, lacrymation, con-

traction of the pupil, and conjunctival congestion. The cornea is turbid and swollen; if ulcerated, it becomes thinned or ruptures and allows the deeper parts to prolapse or escape. If thinned or softened, it may bulge forward from intra-ocular pressure, forming *staphyloma* (*σταφυλί*, a bunch of grapes). After recovery indelible opacities and alterations of curvature (astigmatism) may remain, with corresponding loss of vision.

In the treatment of acute corneal inflammation it is a cardinal rule to *avoid all irritants and caustics,* and to pay special attention to hygiene and the general health. Atropin, shade, and rest of the eyes are always proper. Cold applications and leeches may be used if the symptoms are very acute, but, as a general rule, they are not to be used in corneal affections. Hot applications are better borne and are generally to be preferred to cold in corneal disease.

When the disease does not improve under the above plan, or becomes chronic, the proper treatment requires special experience. Where there is great photophobia and spasm of the orbicularis muscle, the cold douche, forcible stretching apart of the lids, canthoplasty, insufflation of calomel, and ointments of mercury are employed. These latter are chiefly of value in the later stages of acute keratitis. Atropin and hot water are usually efficient in the early periods. When the acute symptoms have subsided, the calomel or a mercurial ointment are usually to be employed to clear up the opacity.

VASCULAR KERATITIS: KERATITIS VASCULOSA.

This is characterized by superficial infiltration and a grayish cloudiness of the cornea, with a network of vessels

traversing the affected region. The epithelium may be shed, causing superficial ulceration, and great pain result from exposure of the nerve-endings. Under favorable circumstances the disease tends to recovery. It may turn into one or the other forms or be combined with them.

PHLYCTENULAR KERATITIS.

This is characterized by *phlyctenules* in the layers of cornea situated between Bowman's membrane and the epithelial layer, and are like those of phlyctenular conjunctivitis; and it is often associated with the latter disease. Phlyctenules appear as inflammatory nodules, single or in groups, on any part of the cornea, but most often at its margin; they may be surmounted by vesicles, which burst and leave small ulcers, or ulcers may result from loss of tissue of the nodule without formation of vesicles. When the eruption is limited, the attendant congestion is partial; a triangular network of vessels is seen running toward the retrotarsal fold and its apex at the phlyctenule, if this is at the edge of the cornea. If the phlyctenule lies some distance from the edge of the cornea, the apex of the triangle appears cut off at the latter—a space of clear tissue intervening between it and the phlyctenule. If the disease is severe, vascular keratitis may supervene, the vessels extending upon the cornea quite up to the phlyctenule. Pain and photophobia are generally marked, the latter symptom often being out of all proportion to the degree of inflammation. In this affection the secretions from the eye irritate and excoriate the parts over which they flow. This disease is most common in weak, scrofulous, and

badly nourished children. It may arise from irritations of the ciliary nerves, either directly or through the fifth pair. It is seen in conjunction with eruptions of herpes or eczema, in the course of the trifacial nerve; also with conjunctivitis and nasal catarrh. In treatment, these eruptions and catarrhs should receive special attention. The other treatment is similar to that followed in phlyctenular conjunctivitis.

INTERSTITIAL, PARENCHYMATOUS, OR DIFFUSE KERATITIS.

This disease is marked by cell proliferation in the deeper layers of the cornea, causing swelling and diffuse cloudiness. Usually it extends from the margin toward the center; rarely the reverse; the cloudiness varies in degree from slight haziness to dense opacity, as of ground glass; usually grayish; may be thicker in some parts than others, causing white or yellowish patches. The surface usually loses its polish, and assumes a dull, stippled appearance from loss of epithelium. Vessels may appear in the substance of the cornea, running from the margin toward the center. They may be so numerous as to cause a bright-red color, like extravasated blood. There is very little tendency to ulceration. The disease usually has a long and tedious course, but after duration of many months a cure may be complete. It has been specially described by Mr. Hutchinson (London) as occurring—together with flat face; notched incisor teeth; and coarse, pallid skin—in inherited syphilis. It is thought by some (Callan, New York) that this disease occurs also in the course of acquired syphilis as well as hereditary. If this be so, it is at least rare. Acquired syphilis rarely, if ever, invades the cornea.

TREATMENT.—The treatment of parenchymatous keratitis, if persistent and thorough, is generally attended by very good results. The general nutrition should be improved in every feasible way. Codliver-oil, Russell's emulsion, or the like should be administered. The oleate of mercury, 20 per cent., should be used as a daily inunction, 1 drachm at a dose. Hypodermic injections of mercury may also be used instead of inunctions. Locally atropin and hot water should generally be used, and calomel insufflations when the acute ocular symptoms have subsided. Months often elapse before a cure is effected, but useful and sometimes excellent vision is regained even when a large part of the corneal surface has been opaque and great photophobia and lacrymation have existed.

SUPPURATIVE KERATITIS.

In this form of corneal disease an inflammatory infiltration becomes changed into pus, which appears as a yellow opacity in the corneal tissue. The suppuration may be limited, or the entire cornea may be changed into a yellow, necrosed mass. If the suppuration is inclosed by corneal tissue it forms an *abscess;* if superficial, an *ulcer.* Sometimes the pus sinks down between the corneal layers to the lower margin of the cornea, presenting an appearance called *onyx* (Gr. ονυξ, nail), or *unguis* (Latin for nail) from the resemblance to the lunula of the finger-nail.

If pus breaks through into the anterior chamber, it forms *hypopyon* (ὑπο, under, and πυον, pus). By oblique illumination, and looking at the cornea in profile, it is generally easy to distinguish between onyx and hypopyon.

Sometimes they coexist. The suppurative process may be attended with vascularity and very acute symptoms, or there may be no vessels and little or no irritation. The latter form is specially dangerous from rapid death and sloughing of the tissue. Abscesses may be absorbed or burst open, or pus may undergo fatty or chalky degeneration, leaving a dense opacity. When an abscess opens, an ulcer results.

CORNEAL ULCERS: ULCERATIVE KERATITIS.

Ulcers also occur superficially without precedent abscess. They are of variable size, shape, and depth, and are dangerous according to their situation and course. A very dangerous form is the crescentic marginal ulcer, which shows a tendency to encircle the cornea and cut off the nutrition of the central parts. Sometimes an ulcer will extend directly across the cornea, and is called serpiginous ulcer, from its tendency to progress from one side while it heals from the other, leaving a bandlike opacity. There is another ulcer, called rodent, that undermines at its edges in all directions, often spreading over the entire cornea, rarely perforating, but leaving a dense opacity and destroying the vision. In small ulcers, extending to Descemet's membrane, the latter may bulge forward through the ulcer like a vesicle, forming *keratocele,* or *hernia of the cornea.* Perforation generally follows. Larger ulcers frequently lead to staphyloma.

If an ulcer goes on to perforation, there is a sudden escape of aqueous humor, which is apt to carry the iris forward into the wound, where it may become firmly adherent during the healing of the ulcer, forming what is called *anterior synechia* (Gr. συν, together, and εκω, to hold). If

the perforation is large, the iris may protrude through it, and become adherent around its edges, leaving a staphyloma. Sometimes after the healing of the ulcer, reaccumulation of the aqueous humor and action of the iris muscle are sufficient to tear loose the adhesions of the iris, and allow it to fall back into its proper place.

The lens may also be carried forward with the iris against the perforation, and when it returns to its position it is apt to carry with it some inflammatory deposit on its anterior capsule, forming an *anterior capsular cataract.* Adhesions of the iris and lens to the posterior surface of the cornea may be so extensive and firm that the anterior chamber is never re-established. Where sloughing of the cornea is very extensive or total, escape of the lens and vitreous and atrophy of the globe may result. Ulcers may be filled up by transparent tissue and heal, without leaving a trace. Slight, superficial cloudiness may remain, which gradually clears up; or a permanent, white, tendinous cicatrix may be left. During the healing process vessels appear running over the cornea to the ulcer.

ABSCESS OF THE CORNEA.

Suppurative inflammation may result from the same causes as in other forms. It is a dreaded result of operations involving corneal incision, especially in the old and feeble. Asepsis in operations upon the cornea has greatly reduced the percentage of suppuration following them, but in patients more than 70 years of age even with the greatest care suppuration may result. Bruised and lacerated wounds are apt to cause it. It is also one of the dangers of purulent

conjunctivitis. It occurs in paralysis of the fifth pair as *neuroparalytic ophthalmia.* Such paralysis renders the cornea anesthetic, hence insensible to action of external irritants, and seems also to exercise unwholesome influence upon its nutrition.

TREATMENT.—The treatment includes ordinary remedies for keratitis. Special cases call for special means. It is not customary to evacuate pus except in hypopyon. Even a large hypopyon is often reabsorbed. It is often essential to keep the intra-ocular pressure reduced. This is done by paracentesis or iridectomy. Paracentesis may be repeated frequently. Fomentations of water are often useful, especially in the asthenic form, where there is danger of rapid death of the tissue. In the neuroparalytic form it is necessary to protect the cornea by a bandage. In deep ulcers it is better to perform paracentesis through their base than to allow spontaneous perforation. In indolent superficial ulcers Saemisch's operation sometimes succeeds. In serpiginous and rodent ulcers, which have a tendency to extend, the best treatment is to curette away the dead tissue and apply pure carbolic acid to the base of the ulcer, being careful not to allow any excess to run on the healthy tissue. Or, better yet, cauterize the sloughing portion with the galvano-cautery or actual cautery, atropin, fomentations, and good diet being also used.

PANNUS.

(Lat. *pannus*, a cloth.)

Pannus is, strictly speaking, a non-inflammatory, superficial, vascular opacity of the cornea—a neoplastic formation left by preceding inflammation. The term, however, is also

applied to acute and chronic vascular keratitis, where formation of new tissue is still in progress. The disease may involve a part or the whole of the cornea. A slight grade is called *pannus tenuis;* a severe one, *pannus crassus.* In extreme degrees the cornea may have a red, fleshy appearance. The disease may continue for months or years without marked change. A complete cure may occur, but it is rare. As a rule, opacities are left, and sometimes the cornea is completely covered by a thick, dry, tendinous membrane. It may also become thinned and bulge forward. The most frequent cause of pannus is trachoma; and the corneal surface may then present granulations like those on the lids. It may be traumatic from long-continued irritation, such as that from foreign bodies, inverted cilia, exposure to dusty atmosphere, and so forth.

The treatment should aim, after removing the cause, to hasten the resolution of the opacity. For this, irritant powders and ointments are used if no inflammation exists. Sometimes the remedies lose their effect and must be changed or intermitted. Inveterate cases are sometimes treated by the operation of *syndectomy,* which consists in removing a strip of conjunctiva and subconjunctival tissue all around the edge of the cornea, so as to cut off the blood-supply from the latter. As has been said, the use of jequirity probably offers more in inveterate cases of pannus than any other form of treatment. (See "Trachoma.")

OPACITIES WITH CICATRICIAL DEPOSIT.

These are frequently the results of corneal inflammation. They may be divided into *superficial* and *deep,* the former affecting the epithelial layer, the latter the parenchyma. A

faint, superficial opacity is called *nebula* (Latin for fog); a thick, dense one *leucoma* (Gr. λευκος, white). A cicatrix, combined with prolapse and adhesion of the iris, is called *leucoma adherens.* White, chalky-looking incrustations may result from a metallic deposit, as where a lead lotion has been applied to an ulcerated cornea. Opacities impair vision according to their situation and according to the alteration of curvature accompanying them. They may necessitate constant straining for vision of small objects, and lead to myopia and strabismus. If they prevent distinct retinal impressions, the eye may become amblyopic from disuse and deviate outward. In children, they may cause nystagmus.

Many times superficial opacities disappear spontaneously, especially in young, healthy subjects. As a rule, the more recent and superficial the opacity, the better the chance of its removal.

Irritants, such as calomel, are used to assist absorption by exciting hyperemia and increased tissue change. Lead deposits are sometimes scraped off with a knife in the hope that the resulting ulcer will be filled up with transparent tissue.

OPERATIONS FOR AN ARTIFICIAL PUPIL.

Where opacities resist all treatment and obstruct vision, one of the operations for artificial pupil may be performed. The new pupil should be made opposite the part of the cornea that is most transparent and of most correct curvature. Where a small part of clear cornea remains over the pupil, vision may often be improved by *stenopeic spectacles* (Gr. στενος, narrow, and οπη, hole), which cut off lateral, diffused rays of light. They are made of metal or ground

glass plates with small central slit, or hole. They contract the visual field greatly, and can only be used for close work.

TATTOOING THE CORNEA.

Unsightly white opacities which cannot be removed are sometimes tattooed with India ink for the cosmetic effect. The operation is performed with a number of fine needles set in a handle so that the points project evenly or on a slanting line; a thick paste of India ink is spread over the opacity and pricked into its superficial layers by the needles, as in ordinary tattooing. Care to wrap the forceps with cotton so as not to injure the conjunctiva must be taken, so as not to stain that membrane.

Diffuse cloudiness of the cornea sometimes results from derangement of the corneal elements by increased intraocular pressure. In certain diseases, such as serous iritis (cyclitis), irido-choroiditis, fine punctate opacities are deposited on its posterior surface or the layer of Descemet's membrane.

CICATRICIAL STAPHYLOMA.

(Gr. *σταφυλη*, bunch of grapes.)

It is generally the result of ulceration. The floor of the corneal ulcer is very apt to yield and bulge forward from intra-ocular pressure. During the healing process the bulging part is covered over with cicatricial tissue, and a bluish-white protrusion, or staphyloma, is left. To this the iris may be partially adherent posteriorly. Or, if perforation occurs, the iris may prolapse, close the wound, protrude through it, and form a basis for the cicatricial deposit. Staphyloma may be partial or total, involving the whole

cornea. If partial, the tendency is to increase. The lens may retain its position, or fall forward and press against the posterior surface of the protrusion. The walls of the staphyloma may be very thin and may burst, or may gradually thicken from fresh inflammatory deposit. Repeated attacks of inflammation and ciliary irritation may occur, and lead finally to sympathetic trouble, especially where the iris is involved and in a state of constant tension. Staphyloma sometimes results from wounds of the cornea and from cataract incisions.

In partial staphyloma the treatment aims to prevent further progress, to reduce the protrusion already existing, and to improve the vision. Repeated paracentesis, with methodical use of a pressure bandage, or iridectomy followed by pressure, may succeed. In very extensive or total staphyloma, splitting or excision may be performed, the lens being also removed. *Splitting* is done by passing the knife through the long diameter of the tumor and allowing the edges to fall together and unite, with a view to producing a flatter cicatrix. Quite a piece of the edges of the wounds should be cut off. *Excision* is performed by cutting the tumor off at its base and allowing the edges of the wound to collapse and cicatrize. Critchett's operation (Critchett, London, nineteenth century) consists in passing several curved needles threaded with silk through the base of the tumor, and cutting the latter off just in front of them. The needles are then drawn through and the sutures all tied so as to unite the edges of the wound and form a flat stump for an artificial eye. This operation is dangerous from the risk of sympathetic ophthalmia if the needles go through the ciliary region. Enucleation is often preferable. It is

imperatively indicated where there is so much ciliary irritation as to endanger the fellow-eye.

CONICAL CORNEA: KERATOCONUS.

Conical cornea is a cone-shaped staphylomatous protrusion of the cornea whose cause is not well understood. The cornéa is thinned and less resistant, but the intraocular pressure is generally not increased and is sometimes below normal. The affection comes on, as a rule, very slowly, and without pain or irritation; it may remain stationary or advance to a high degree, in which case the apex becomes extremely thin and is apt to be clouded; but it never bursts, except from violence. The first symptoms noticed by the patient is impairment of vision, as the eye becomes myopic from lengthening of the axis, and astigmatic from irregular curvature of the cornea. In high grades, astigmatism causes great distortion and reduplication of the images. Slight grades are often overlooked; high degrees may be easily seen, especially in profile. If the eye is illuminated by the ophthalmoscope, a central red reflex is seen surrounded by a dark ring, outside of which is a second bright-red ring. By throwing light from different angles, the side of the cone opposite the light is seen in shadow. If the fundus is examined, everything appears distorted.

The *treatment* is unsatisfactory. There is but little improvement of vision from glasses. The hyperbolic glasses of Raehlmann are sometimes of benefit, when others fail. The stenopeic slit is occasionally of use. All straining of the eyes must be avoided. Operative treatment comprises iridectomy, iridodesis, trephining, electrocautery, and Graefe's operation, which consists in removing a superficial

flap from the apex of the cone and cauterizing the part a few times with nitrate of silver, so as to produce a shrinking cicatrix and so flatten the protrusion. Conical cornea usually occurs in debilitated anemic subjects, and a positive indication is to look after the general health by careful hygiene.

KERATOGLOBUS: HYDROPHTHALMIA: BUPHTHALMOS.

(Gr. βούς, an ox, and, ὀφθαλμός, eye.)

This is a uniform spherical bulging of the entire cornea and neighboring part of the sclerotic, usually associated with increased size of the anterior chamber and tremulous iris and lens. The condition is generally congenital. It may appear after inflammation. The cornea may remain transparent or become cloudy, especially at its margin. It causes great impairment of vision, changes in the deeper tissues, and often ultimate blindness. Treatment is of little use. Iridectomy seems to do the most good, and should be performed when there is increased tension or continued growth of the globe.

FISTULA OF THE CORNEA.

This may result from a wound or a small perforating ulcer, and is very difficult of cure. The aqueous continually drains away, and the eye is kept irritated. The treatment comprises the dropping in of atropin, touching the fistula with nitrate of silver, bruising its edges with fine forceps to excite healing, compress bandage, and iridectomy.

The Sclera.

EPISCLERITIS.

This appears as a dusky-red swelling on the sclera near the edge of the cornea, oftenest on the temporal side. It shows no tendency to ulcerate or suppurate. There may be dull pain with ciliary irritation and tenderness. The disease is an obstinate one. Remedies for syphilis and rheumatism, and atropin or pilocarpin locally, and the latter hypodermically for constitutional effect, are most useful. The disease has a tedious course, but it is usually curable.

STAPHYLOMA.

Staphyloma of the sclerotic generally results from inflammations which weaken the tissue so that it yields to the intraocular pressure. It may be *anterior*, between the cornea and equator, or *posterior*, around the optic nerve. Anterior staphyloma has a dirty-bluish color from the pigment of the ciliary body and choroid shining through it, and is of variable size, sometimes involving the whole front of the eyeball. Where the tumor is small, iridectomy or paracentesis, with a pressure bandage, may be tried to check further progress. It may be cut off in the same manner as a corneal staphyloma. If very extensive, it may be necessary to remove the eye. Posterior staphyloma generally occurs in myopic eyes.

WOUNDS.

Wounds of the sclera are dangerous according as they implicate neighboring tissues and allow the contents of the eye to escape. Those near the ciliary region are espe-

cially dangerous and, if the ciliary body is implicated, often require enucleation of the eyeball to prevent sympathetic inflammation in the fellow-eye. Small wounds may heal readily. Cleanly cut wounds may be united by fine sutures, any protruding choroid or vitreous being cut off by scissors, and with the strictest aseptic precautions as to cleanliness of the instruments and point of the operation.

The Iris.

Simple wounds may heal readily or may set up iritis. A severe blow upon the eye sometimes causes the iris to rupture at its circumference—*coredialysis* (Gr. χόρη, pupil, and διαλύσις, rupture), or *iridodialysis,* forming a secondary pupil, which usually remains permanent.

Foreign Bodies.—The best way of removing one is by excising the portion of iris in which it lies.

Prolapse of the Iris is a frequent result of perforating wounds of the cornea. If the prolapsed tissue cannot be replaced it must be cut off. Atropin should be frequently applied. The galvanocautery also forms a good method of treating a prolapse of the iris. Prolapse of the iris after the removal of the lens in a cataract operation should be excised at once. If too long a delay occurs (two or three days), it is better to leave the prolapsed portion to cicatrize in the wound.

IRITIS: INFLAMMATION OF THE IRIS.

This is caused by injuries, cold, syphilis, gonorrhea, rheumatism, tuberculous exudations, and extension of inflammation from other parts. The conjunctiva is suffused and a rosy zone of fine, subconjunctival vessels appears

around the cornea, radiating in parallel lines from its margin. The iris appears dull, blurred, and discolored (a light iris becoming greenish; and dark one, brownish red), and its movements are sluggish. This is caused by turbidity of the aqueous humor from admixture with lymph or pus. The pupil is contracted and its edges may become glued by exudation to the anterior capsule of the lens. Such adhesions are called *posterior synechiæ* (Gr. σὺν, together, and εχω, to hold). They may not be detected until atropin is applied, when the pupil dilates irregularly and shows adhesions at one or more points. When the whole circumference of the pupil is thus adherent, the condition is called *exclusion of the pupil.* When the exudation encroaches upon the *area* of the pupil, the condition is called *occlusion of the pupil.* In syphilitic iritis yellowish-red nodules, analogous to gummy tumors, may appear upon the surface of the iris. Sometimes the exudation is chiefly serous, the intra-ocular tension is increased (glaucoma), and there is less tendency to synechiæ; the pupil is dilated and there is often a deposit of lymph particles on the posterior surface of the cornea. The condition is then called *serous iritis, descemetitis, aquo-capsulitis,* or *simple cyclitis.*

The pain in iritis is variable; it may be very severe, and extend over the forehead, temple, and side of the nose *(ciliary neuralgia),* or it may be entirely absent. Photophobia and lacrymation are not always severe. The vision is always impaired. From the close connection of the iris, choroid, and ciliary body, the inflammation readily extends from the former to the latter and *vice versa.* If, during iritis, the ciliary body becomes involved *(iridocyclitis),* there is great tenderness over the ciliary region—a symptom not present

in simple iritis. If the choroid becomes involved *(irido-choroiditis)*, the symptoms are all the more serious and the prognosis is worse; the vitreous is clouded, and there is loss of vision and contraction of the field of vision not explained by iritis alone. This condition is most common in eyes which have suffered several attacks of iritis, leaving behind extensive synechiæ. Where the cornea and iris are both inflamed, the disease is called *kerato-iritis.* If synechiæ are left after iritis, the iris is impeded in its movements and constantly dragged upon by adhesions; free communication between the anterior and posterior chambers is interrupted and the natural balance of pressure destroyed. This condition tends to keep up a chronic irritation and to cause frequent relapses, which may finally destroy the eyesight.

Treatment.—Perfect rest of the eye and protection from the light are necessary. The chief local remedy is atropin. This keeps the pupil dilated and away from the lens, so that adhesions cannot form; it puts the inflamed tissue at rest by paralyzing its muscles; it contracts the blood-vessels and lessens the tension. Its action is resisted in inflammation, and a strong solution should be used (4 to 15 grains to the ounce). This may be applied at intervals of a few minutes until full dilation of the pupil is obtained, which should then be kept up by instilling a 2- to 4-grain solution three or four times a day—even some days after the inflammation has subsided. Even where adhesions have already formed, atropin may cause them to be stretched and broken, if they are not too firm. When there is increased tension and great irritation, atropin may produce no effect until a paracentesis of the cornea has been performed. This is always indicated in such a condition, and may be repeated several

times if beneficial. Sometimes atropin acts better after the application of leeches to the temple, which relieves the local blood-pressure, and after the patient has been brought under the influence of mercury. If atropin produces poisonous effects, it must be stopped at once. Scopolamin often may be used when atropin is irritating. Leeches and fomentations are generally useful where the attack is very acute. It is also essential to give anodynes enough to quiet the pain. In syphilitic iritis, and in other forms where there is a great tendency to plastic effusion, the patient should be brought promptly under mercury—preferably by inunction—and iodid of potash may be given at the same time. Cocain in a 2- or 4-per-cent. solution, instilled five to eight times a day, is a valuable adjuvant to atropin in the treatment of this disease.

It is in chronic iritis of a low degree of intensity that atropin long continued in rare cases becomes a local irritant. The surgeon should be always on the lookout for the symptoms of such an irritation when a long-standing case is not steadily, if slowly, clearing up.

TUBERCULOUS IRITIS.

Recent investigations make it probable that tuberculosis of the iris is sometimes very hard to diagnosticate until too late, being confounded with syphilitic exudation on the iris. In some cases the appearances are so nearly like the latter that it is almost impossible to make an exact diagnosis except by treatment. If a case showing a small, grayish nodule on the iris is presented and there are other evidences of constitutional infection, either congenital or acquired, it will be proper to commence the treatment by mercury, but if the

local condition imitates syphilitic disease, while the general conditions do not point to syphilis, it is better to begin with the treatment for tuberculosis. If the treatment with mercury fails in a case supposed to be one of syphilitic growth, it will then be proper also to take up a treatment adapted to tuberculosis. Abadie (Paris) has had good results in a small number of cases which were in the beginning supposed to be syphilitic by giving iodogonol in doses of 30 drops a day, as well as the Carnine Lefranc as a nutrient.

The results are very good if the diagnosis of tuberculosis can be made early, and the treatment with iodin and nutrients be taken up, while mercury will be of no service. Tuberculous iritis is very rarely reported in this country.

MYDRIASIS: DILATION OF THE PUPIL.

The chief causes are increased tension, paralysis of the third nerve, irritation of the sympathetic, disease of the optic nerve and brain, the action of certain drugs, such as hyoscyamus, belladonna, and stramonium. The mydriasis is generally confined to one eye, and may be uniform or partial. When not caused by drugs, the pupil usually is not dilated to the maximum and has a sluggish action. Even an external application of belladonna, for example, in a plaster may cause what will be an alarming symptom to the patient—dilation of the pupil and impairment of the vision especially for the near point.

MYOSIS: CONTRACTION OF THE PUPIL.

(Gr. μύως, to close.)

This is caused by irritation of a branch of the third nerve supplying the sphincter of the pupil, by paralysis of

sympathetic filaments to the dilator of the pupil (such as occurs in spinal lesions), by constant work at minute objects (as in watchmaking), by certain drugs, such as Calabar bean, opium, and so forth. The treatment of mydriasis and myosis depends on the cause.

HIPPUS.

(Gr. ἵππος, horse?)

This is chronic spasm of the iris causing rapid, alternating contraction and dilation of the pupil, independent of the stimulus of light. It is generally associated with nystagmus.

IRIDODONESIS, OR TREMULOUS IRIS.

(Gr. ἶρις, rainbow, and δονέω, to tremble.)

This is marked by trembling of the iris when the eye is moved about. It is caused by a loss of support of the crystalline lens from whatever cause.

CYSTS OF THE IRIS.

These are rare and generally the result of some injury. They appear as transparent vesicles on the surface of the iris, attached by a broad base or pedicle. The best treatment is to excise the portion of the iris to which the cyst is attached.

MALIGNANT DISEASE OF THE IRIS.

This is occasionally observed, generally as a sarcoma. The eyeball should be removed.

CONGENITAL DEFECTS OF THE IRIS.

These comprise *irideremia* (Gr. ἶρις, rainbow, and ἐρημός, wanting), or absence of the iris; *coloboma* (Gr.

κολοβωμα, mutilation), or cleft iris; *corectopia* (Gr. κορη, pupil, and εκτοπος, out of place), or eccentric position of the pupil; and *polycoria* (Gr. πολυς, many, and κορη, pupil), or mutilated pupil, besides different pigmentation of the two irides.

THE CHOROID.

RUPTURE OF THE CHOROID may result from blows upon the eye, with or without laceration of the other tunics. The accident is generally followed by hemorrhage and inflammation, with corresponding impairment of the vision. The blood may be confined to the choroidal stroma itself or penetrate between it and the sclerotic or retina, or into the vitreous humor. Choroidal hemorrhages seen with the ophthalmoscope appear as uniform red patches, lacking striation and the feathery edges of extravasations into the fiber layer of the retina. Sometimes the retinal vessels may be seen running over them. Rupture, if seen at all, appears as a pale, irregular streak, with dark edges, from pigment and extravasated blood. In some cases the blood is absorbed, the wound heals, and a good recovery results. *Treatment* consists in keeping the eye quiet with atropin and a bandage, and promoting absorption of the blood by such means as cold dressings, compress bandage, and leeches to the temple.

CHOROIDITIS: INFLAMMATION OF THE CHOROID.

This is rarely independent, but is usually associated with inflammation of the iris, ciliary body, or retina.

DISSEMINATED, OR EXUDATIVE CHOROIDITIS.

This is marked by circumscribed, yellowish spots of exudation on the surface and in the stroma of the choroid. Retinal vessels may be seen running uninterruptedly over them, and the intervening tissue may appear healthy. Exudations often appear first at the periphery of the fundus and advance toward the center. They may increase in size and coalesce, forming larger patches. The vitreous often contains opacities and the retina may suffer atrophy from pressure of exudation. When the exudations are absorbed, corresponding portions of the choroid become atrophied, allowing the sclerotic to shine through and forming glistening, white spots. The borders of these spots are often black from collections of pigment, and blood-vessels are often seen running across them. The vision is impaired, and the field contracted and interrupted by scotomata. The disease is often due to syphilis.

Treatment.—Rest of the eyes, and protection from the light by blue or smoked glasses. In both syphilitic and simple forms mercury and iodide of potash are beneficial, combined with tonics if necessary. The eyes may be leeched occasionally, if the patient is not anemic. Sweating by pilocarpine injections is beneficial in the serous forms of choroiditis.

SUPPURATIVE CHOROIDITIS: PANOPHTHALMITIS: INFLAMMATION OF ALL THE TISSUES OF THE EYE.

This usually results from injuries, especially from a foreign body entering the eyeball; from operations; suppurative inflammation of the cornea and iris; metastasis during

typhus; cerebro-spinal meningitis; pneumonia; puerperal fever; pyemia, and so forth. It is a most acute and violent suppurative inflammation, involving the whole eye. The lids and conjunctiva are swollen, red, and edematous; the cornea becomes cloudy; the aqueous turbid; the iris pushed forward; the pupil dilated or blocked with lymph; the vitreous, retina, and uveal tract infiltrated with pus; the tension increased and the globe is very painful and tender. The disease, as a rule, ends in total destruction of the eye and atrophy of the globe.

Treatment.—Cold and leeches applied at first, atropin instilled, canthotomy performed to relieve pressure of the lids, and paracentesis to relieve tension and give exit to the pus. Poultices are sometimes applied to relieve pain and hasten the suppuration. Subconjunctival injections of mercury or of saline solutions may be tried. Free incisions are sometimes useful. Enucleation of the eyeball is dangerous on account of exciting meningitis; evisceration is better.

SEROUS CHOROIDITIS.

A serous form of choroiditis sometimes occurs in connection with serous iritis. The symptoms of inflammation may be very slight, but the vitreous and aqueous are cloudy, obscuring the fundus and impairing vision. The tension varies, but may increase to such an extent that other glaucomatous symptoms appear. When the media clear up, no changes may be apparent except posterior polar cataract.

Treatment.—Rest, colored glasses, atropin, leeches, paracentesis or iridectomy if the tension be increased, and hypodermic injections of pilocarpin to produce sweating are the measures to employ.

SCLEROTICO-CHOROIDITIS POSTERIOR: SCLERECTASIA POSTERIOR: POSTERIOR STAPHYLOMA.

This may be defined as an elongation of the posterior half of the eye, with stretching, inflammation, and atrophy of the choroid and the retina. The precise etiology is disputed. It occurs commonly in highly myopic eyes and leads to still further increase of the myopia. It also occurs very rarely in hypermetropia. The predisposition seems to be congenital; the exciting causes are strong efforts of accommodation and convergence for near vision, and continued hyperemia of the posterior scleral zone. It may be stationary or progressive. In the former case the ophthalmoscope shows a more or less regularly shaped crescent at the outer edge of the optic disc (or a zone extending nearly or quite around the disc) of glistening white color, from the sclerotic shining through the atrophied choroid, and with the edges well defined and fringed with pigment; retinal vessels are seen running over it. The myopia does not increase and the eye is not painful or irritable. But, if the affection is progressive, inflammatory symptoms are added; the edges of the crescent are congested and blurred; additional white patches appear about it and unite with the original one; the vitreous becomes turbid, the myopia increases, the eye is irritable, and the vision impaired. Glaucoma, detachment of the retina, or choroidal hemorrhages may supervene. Sometimes crescentic atrophy of the choroid occurs without any staphyloma of the sclerotic.

Treatment.—In the active form complete rest of the eyes is insisted upon; colored glasses should be used; avoidance of all causes of congestion advised; cold douche, leeches, and atropin may be employed.

TUMORS OF THE CHOROID.

These are chiefly varieties of sarcoma. They appear first as a small nodule, which may increase till it fills the globe, bursts through the cornea, and appears externally as an ulcerated, bleeding surface. In their progress they may cause increased tension, and may thus be mistaken for glaucoma. They tend to recur and to invade the neighboring tissues.

Treatment.—Enucleation of the eye as soon as the tumor is detected. If the orbital tissue is affected, as much as possible should be removed and the remaining surface cauterized.

TUBERCLES IN THE CHOROID.

These are occasionally found in acute tuberculosis. They appear as minute, circumscribed, rose-colored or whitish spots, and produce little or no loss of vision. Or they may appear as one large tubercle which may destroy vision and call for enucleation of the eyeball.

DEPOSITS OF BONE IN THE CHOROID.

These are sometimes found in eyes which have been long atrophied. They form an indication for removal of the globe, as they often are painful and cause sympathetic ophthalmia.

COLOBOMA OF THE CHOROID.

This generally co-exists with coloboma of the iris and ciliary body. There may be bulging outward of the corresponding part of the sclerotic. With the ophthalmoscope it

appears as a brilliant white cleft in the fundus, with well-defined edges, running from the ciliary region toward the disc. Retinal vessels may run straight across the white line or be seen dipping on to the exposed portion of the sclerotic.

The Ciliary Body.

CYCLITIS: INFLAMMATION OF THE CILIARY BODY.

(Gr. κύκλος, a circle.)

This occurs generally in connection with iritis and choroiditis, but may also come from injury. The diagnostic symptom is pain over the ciliary region, especially when this is pressed upon. There is also a zone of ciliary injection around the cornea, photophobia and lacrymation, enlargement of the veins of the iris, increase of tension, turbidity of the aqueous and vitreous, loss of accommodation, and impairment of vision. Exudation may be serous, plastic, or purulent. *Traumatic cyclitis* is caused by wounds in the ciliary region, lodgment of a foreign body in the eye, a dislocated lens, and so forth. It may result in fatal suppuration and atrophy of the globe in spite of every precaution, and may also cause sympathetic inflammation of the other eye. Leeches, hot or cold applications, and atropin may be tried, but if the disease progresses unfavorably removal of the eye is advisable, to insure safety of the other one. Hypodermic injections of pilocarpin are often very efficient and may save the eye. Cyclitis occurring in the course of iritis or choroiditis requires the same treatment as those affections, and a perfect cure may result.

THE RETINA.

HYPEREMIA of the retina is caused by prolonged exposure of the eyes to bright light; by fine work; especially where there is a refractive defect; and by inflammation. The fundus looks too red; the papilla is pinkish and its outlines indistinct. The arteries may be a little enlarged, and the smaller branches more numerous than usual, and the veins generally pulsate. The eye is irritable, easily fatigued, and dreads the light. The indications are to remove the cause, put the eye at rest, and protect it by colored glasses. Leeches and cold douche may be useful.

Passive venous congestion occurs from any obstruction to the outflow of venous blood. The veins appear large, dark, tortuous, and pulsating.

HYPERESTHESIA OF THE RETINA.

When not dependent on inflammation this is most commonly caused by straining of the eyes in fine work, by exposure to a very intense light, and so forth. The patient is unable to use his eyes, owing to dazzling sensations, phosphenes, morbid persistence of retinal impressions, lacrymation, spasm of the orbicularis muscle, and ciliary neuralgia. Very rarely with these symptoms there is *nyctalopia* (Gr. νὺξ, night, and ὄψις, vision), or the power of reading by very faint light. Otherwise, the eyes may appear perfectly normal. The treatment consists in rest of the eyes, colored glasses, tonics, and allaying of all nervous excitement. If there is a refractive defect, it should, of course, be corrected.

ANESTHESIA OF THE RETINA.

This is a blunting of the retinal sensibility without any perceptible organic change. The most common causes are the prolonged exposure to intense light, lightning stroke, concussion of the eye or head, disuse of the eye (as in squint), neuralgia of the fifth nerve, and old age. Distinctness of vision is impaired, especially in feeble light—hemeralopia (Gr. ἡμερα, day, and ὄψις, vision).

Treatment.—The treatment must depend on the cause. A perfect cure often results. In anesthesia from disuse, systematic exercise in reading with the affected eye is beneficial and important.

It is sometimes difficult to differentiate retinal irritation from asthenopia from an uncorrected error of refraction. The observer should be guarded against giving a positive prognosis in such case until a little time has been given to the examination.

RETINITIS: INFLAMMATION OF THE RETINA.

This disease may be caused by severe exposure to bright light or continued occupation in fine work; syphilis; Bright's disease; rheumatism and extension of inflammation from other tissues; embolism of the central artery; injury and so forth. It is usually associated with inflammation of the optic nerve (neuro-retinitis). It may also be combined with inflammation of the choroid and vitreous. It generally affects the connective tissue primarily, and extends later, if at all, to the nerve-elements. An inflammatory product infiltrates the tissues and appears as an exudate upon the surface, being evenly spread over it or collected into irregular patches.

The retina is swollen and edematous. The tissue and vessels may undergo sclerosis, fatty degeneration, and atrophy. Extravasations of blood often occur; they are most common in the inner layers, but they may extend to the choroid or into the vitreous; may be absorbed or changed into an opaque, degenerated mass. When the hemorrhages are very extensive the condition is called *retinitis apoplectica.* (Retinal apoplexy may also occur without inflammation, from injury or atheroma of the vessels.) In retinitis of Bright's disease *(retinitis albuminurica* or *nephritica)* there is a large amount of exudation, which soon becomes fatty, in the region of the papilla, and there are also numbers of white, glistening, stelliform spots scattered about; and hemorrhages are numerous. In retinitis in the course of syphilis there may be numerous white, punctiform opacities, especially in the region of the macula, while hemorrhages are not likely to occur. In retinitis of leucocythemia (retinitis leukæmica) there are round, yellowish-white patches, sometimes with red borders, strewn about the periphery of the retina and near the macula—formed from masses of exuded white and red blood-corpuscles; the fundus has a pale-yellow tint, and the arteries look pale and bloodless. Suppuration of the retina scarcely ever occurs except in panophthalmitis.

OPHTHALMOSCOPIC APPEARANCES.

The *ophthalmoscopic appearances* of retinitis are: opacity of the retina, varying in degree from that of a fine mist or film to that of a dense, white patch of exudation. The vessels are obscured the more the opacity lies in the inner layers. The disc looks blurred, especially at its edges. The arteries are usually of normal caliber, but the veins are dis-

tended and tortuous. Blood-extravasations appear as irregular, red patches; if in the inner layers, among the nerve-fibers, they are striated and have feathery edges; if in the outer layers, they appear more smooth and uniform. Externally, the appearance of the eye is usually normal. The vision is impaired according to the severity of the inflammation and the extent to which the nerve-elements suffer. Sometimes it remains normal, while the ophthalmoscopic appearances are very marked. A very common complaint is that everything is seen through a mist or haze. The pain is generally slight. The disease may run an acute or a chronic course, and end in recovery or in incurable atrophy and blindness.

Treatment.—Complete rest of the eyes is enjoined, colored glasses ordered, and special attention directed to the general health. Leeches are applied to the temple in the acute stages, and confinement to the house and in a darkened room insisted upon. Small doses of mercury sometimes act well.

RETINITIS PIGMENTOSA: PIGMENTARY DEGENERATION OF THE RETINA.

This is generally hereditary and associated with other bodily defects. It begins in early childhood, and runs a very slow course, usually affecting both eyes. It is often combined with *posterior polar cataract.* The characteristic ophthalmoscopic appearance is a peculiar deposit of pigment scattered over the retina, appearing as irregular, stellate, black spots, with branching processes (something like bone-corpuscles in form) and as small, black lines showing a tendency to follow the course of the vessels. The retina and the disc are atrophic in appearance and the ves-

sels are small. The choroid also is atrophied in some cases. There is a gradual contraction of the visual field and increasing torpidity of the retina. About the first symptom noticed is hemeralopia. Treatment is usually of no service. Strychnin is recommended. Some cases of retinitis pigmentosa in well-nourished persons pass through a long life without much advancement, so that the patient has sufficient vision—although in a small field—for the ordinary purposes of life.

DETACHMENT OF THE RETINA.

This affection is caused by effusion of inflammatory material or blood between the choroid and the retina; by loss of its support from diminution in bulk of the vitreous; by elongation of the eye, as in myopia; by tumors beneath it; by concussion from blows on it; by contraction of scar-tissue, and so forth. It may be partial or complete.

OPHTHALMOSCOPIC PICTURE.

With the ophthalmoscope an ordinary partial detachment appears as a tremulous, bluish-gray sac projecting into the vitreous, with retinal vessels bending over it, and surrounded by a red choroidal reflex. Very small detachments may appear as fine, gray streaks. In total detachment no reflex can be obtained from the fundus at all and the light-streak on the retinal vessels is absent. The symptoms complained of are a floating cloud before the eye, metamorphopsia, and loss of vision in the part of the field opposite to the detachment. Thus, if the lower half of the retina is detached, the upper half of the field will be absent. The prognosis is unfavorable. The tendency of detachment is

to increase. Only exceptionally it ruptures or subjacent fluid is absorbed and the retina falls back into place and some degree of sight is restored.

Treatment.—The treatment is chiefly expectant. Success has been reported from keeping the patient for a long time on his back with eyes bandaged, atropin instilled, using hypodermic injections of pilocarpin; and also from the operation of passing a needle or cataract knife in through the sclera and opening the sac so as to allow the fluid to escape and the retina to fall back into place.

Detachment of the retina usually means, except in traumatic cases, that an unsound condition of the eye, especially of the vitreous, has preceded the accident, hence the usually unfavorable prognosis.

EMBOLISM OF THE CENTRAL ARTERY OF THE RETINA.

This causes sudden blindness without pain or irritation. The optic disc appears blanched, and the retinal vessels reduced and more or less bloodless. The arteries may appear as small white threads; veins small and irregularly filled. Soon the retina becomes opaque, except at the fovea, which appears as a cherry-red spot from choroidal reflex. The condition ends in atrophy of the nerve and retina, and is irremediable.

Embolism of the retina usually occurs in one eye only, and is scarcely ever followed by the same condition on the other eye. One branch only of the retinal artery may be affected, when the corresponding part of the retina supplied by this branch is affected, as no anastomosis takes place between the retinal arteries, the retinal circulation being peculiar in this respect.

EPILEPSY OF THE RETINA.

This is characterized by sudden dimness of vision, advancing from the periphery of the field toward the center, until total blindness results, which lasts generally but a few minutes, and then completely disappears. The attacks occur at variable intervals, and affect one or both eyes. The condition is supposed to be due to spasm of the retinal vessels. It is a rare disease.

TUMORS OF THE RETINA.

Glioma (Gr. γλὶα, glue) is composed of round, spindle-shaped, and branching cells, with granular, intercellular substance, and originates in the retinal connective tissue. It occurs almost exclusively in young children, and is often unnoticed until far advanced. It appears as a yellowish tumor projecting into the vitreous. The surface is vascular, and the retina in the vicinity detached. The eye may look normal externally and be painless, but vision is lost. As the tumor grows, it fills the globe, presses forward the iris and lens, bursts through the cornea, and presents externally a fungous, bleeding surface, occasioning great suffering. Excision of the eye is the only remedy, and that is often temporary, since the disease usually recurs in other parts of the body. Disease may recur in the orbit or extend back to the brain.

The Crystalline Lens.

CATARACT.

Cataract is an opacity of the crystalline lens caused by an interference with its nutrition. It may thus result from senile involution; from debilitating disease, such as diabetes; from inflammation, especially of the uveal tract,

which cuts off the blood-supply or extends to the lens itself—*phakitis* (Gr. φακός, lens), or from injury, perhaps also from uncorrected errors of refraction, which cause strain of the accommodation. It is apt to occur in certain families and thus is sometimes assumed to be an hereditary disease.

Ergotism has been observed as the cause, but the precise mode of action is not understood. In the majority of cases cataract occurs after 45 years of age, but it may occur at any age, and is sometimes congenital. Many forms are described, but the most practical division is into: 1. *Soft,* or *cortical, cataracts,* occurring below middle age, and of soft consistence throughout. 2. *Hard,* or *nuclear, cataracts,* occurring after middle age, and containing a dense nucleus. The opacity generally begins at the margin of the lens and advances as fine stripes or dots toward the center, until at last the whole lens is opaque, and the cataract is said to be *mature,* or *ripe.* Soft cataract usually progresses rapidly, especially in children. After reaching maturity it may undergo secondary changes; the more fluid parts may be absorbed and the remainder become a small, shriveled disc of fatty or chalky consistence; or the fluid parts may increase so that the capsule is filled with milky liquid. A cataract with fluid cortex and hard nucleus is sometimes called a *Morgagnian cataract.* It is this form that is most likely to become absorbed. Yet this termination is very rare and tedious when it does actually occur.

TRAUMATIC CATARACT.

This is soft cataract following injury of the lens and developing usually with great rapidity. The most frequent causes are wounds which perforate the capsule and

allow the aqueous humor to reach the lens substance, which becomes soft and opaque, and may swell to such an extent as to press upon the neighboring parts and excite dangerous inflammation—one of the forms of secondary glaucoma. In more favorable cases it may be wholly or partially absorbed. Traumatic cataract may also result from simple concussion, without any rupture of the capsule.

CAPSULAR CATARACT.

Partial cortical cataracts may occur, and are often called *capsular cataracts.* They are usually not due to changes in the capsule, but to changes in the cortex near its inner surface. After iritis or perforating ulcer of the cornea, a deposit of lymph is often left on the anterior capsule of the lens. Superficial lens matter just beneath may also suffer in its nutrition and becomes opaque, while the intervening capsule remains transparent. This is called *anterior central capsular cataract.* If it projects much above the capsule it is called *pyramidal cataract.* An opacity of the cortical substance lying upon the posterior capsule, or a deposit of lymph upon the latter from the vitreous, is called *posterior polar cataract,* and is much less frequent. Sometimes a single layer of lens-fibers becomes opaque, while the remainder retain their transparency. This form is called *laminated, lamellar,* or *zonular cataract,* and is most common during infancy and youth. It may remain stationary or become complete.

SENILE CATARACT.

Nuclear, hard, or *senile cataract* is distinguished by a hard central portion, or *nucleus,* surrounded by a less dense

layer of cortical substance. As the cataract progresses, the distinction between cortex and nucleus becomes more and more evident, the latter appearing as a round, central patch of greater or less size and of yellowish color. The progress is usually slow, years often elapsing before the cataract matures. Retrogressive changes may occur, as in the soft form. The soft cortex may undergo absorption or fatty and chalky degeneration, while the nucleus becomes harder. The capsule is then apt to become tough and adherent. The name *black cataract* has been applied to a very rare form, where the color of the lens is very dark. In this form the lens-fibers become sclerosed, and do not undergo degeneration as in true senile cataract.

Diagnosis of Cataract.—A fully formed cataract is easily seen, as the pupil is filled by a grayish opacity. Incipient or partial cataract may be seen by oblique illumination or with the ophthalmoscope. If the latter is used, the mirror only is employed, when, on illuminating the eye, any cataractous opacities appear as black spots against a red background. To insure thoroughness, the pupil should be dilated by euphthalmin or cocain. Complete soft cataracts, when seen by oblique illumination, present a bluish-gray opacity slightly denser at the center than at the margin. In hard cataracts the opacity presents a yellow nucleus surrounded by grayish cortex. In the pure lamellar cataract the opacity is uniform and sharply marked off from the transparent border and overlying strata of lens. With the ophthalmoscope, the opacity appears as a dark disc, and light shines through it from the fundus. The vision is impaired just according to the degree and situation of the opacity. When cataract is congenital or has developed in childhood, the lack of vision

may cause loss of functional power of the retina, or muscular derangement, such as strabismus and nystagmus. In cataracts appearing after puberty these defects are seldom seen.

Treatment.—Medicine and general hygiene accomplish nothing except in the way of improving the general health, and so impeding the progress of the opacity. While the cataract is maturing, the vision may be temporarily improved by dilating the pupil, by shading the eye from light. In partial cataracts which have become stationary, an operation for artificial pupil may be performed to expose the clear portion of the lens. Complete cataract may be removed by one of several operations. If degenerative changes have occurred, removal of the lens is more difficult. Before operation, the vision and visual field should be tested, for, if the function of the retina has been lost, the operation is useless and unjustifiable. The progress of cataract may be hastened by opening the capsule with a needle, so that the aqueous humor may act upon the lens. In traumatic cataract from rupture of the capsule, the eye should be treated with atropin and bandage, just as if a needle operation had been performed. If the lens matter swells excessively, it should be evacuated at once through a corneal incision. The chief bad results from extraction of cataract are suppuration of the cornea, iritis, irido-choroiditis, prolapse of the iris, and imperfect union of the corneal wound. After the lens has been removed, the cornea is the only refracting surface left, and strong convex glasses are needed to give acute vision, except in rare cases, where the eye was very highly myopic before the operation. The accommodation is much limited after removal of the lens, but there is some range in near vision. Where the lens has been removed from only one eye, and the

other is normal, spectacles cannot be used, because of very different refraction of the eyes. Still, the eyes sometimes adapt themselves to the new condition and work fairly well together.

SECONDARY CATARACT.

Secondary cataract is the name applied to opacities which appear in the area of the pupil after the lens has been removed. It also applies to cataract following another disease of the eye. Opacities may be in the capsule or due to lymph deposit from iritis, or to particles of lens matter left behind from the operation. The capsule may cause impairment of vision by becoming wrinkled, without being opaque. Operations for such secondary cataract consist in cutting across the membrane with a knife-needle; or if the membrane is very dense, an incision with angular keratome is made in the cornea, and the membrane cut across with the Wecker scissors, or bodily removed with iris forceps (Panas).

The corneal astigmatism occurring from the section of the cornea should be carefully corrected some three months after the operation. The vision is usually steadily improved by the addition of properly chosen cylindrical to the spherical glasses.

DISLOCATION OF THE LENS.

Ectopia Lentis (Gr. εκ, from, and τοπος, place).—This generally results from injury, but it may be spontaneous, and also congenital from weakening of the suspensory ligament. It may be complete or partial. In the latter form, the lens may be moved to one side, so that its margin crosses the area of the pupil, or it may be merely rotated on its axis.

The iris is tremulous where the support of the lens is lost. The vision is greatly disturbed. An artificial pupil may be made in a more favorable place or the eye fitted with glasses, as after cataract operation, or the lens may be extracted, especially if it causes irritation. In total dislocation (1) the lens may lie in the anterior chamber; (2) in the vitreous, where it is apt to act as a foreign body, and may cause sympathetic trouble; (3) under the conjunctiva, which only occurs where a heavy blow has ruptured the sclerotic, leaving the conjunctiva intact. In all cases of total dislocation the lens should be removed at once if possible.

Lenticonus, or conical lens, is occasionally seen. Webster reported the first case in 1875.[1] It is an irremedial condition, except in so far as the irregular astigmatism may be corrected with glasses. It is apt to occur in one eye only.

The Vitreous Humor.

Foreign bodies lodged in the vitreous usually excite dangerous inflammation and may cause sympathetic disease. Very rarely they become encapsulated and remain harmless for a long time.

The *use of magnets* has greatly increased the facilities for removing metals from the eye. Magnets of very great power are now used (Haab, Zurich) and many eyes are saved that were formerly lost. Foreign bodies of iron or steel are extracted from the anterior parts of the eye, as well as from the lens and vitreous humor. The end of the magnet must taper to a small point, so that it can be approached to the eye, or the point introduced within the eye if the magnet is a small one. It is very useful as a probe for explor-

[1] Archives of Ophthalmology and Otology, Bd. iv, page 382.

ing the wound for a piece of metal which cannot be seen. Or it may be introduced through an incision specially made for it. By being moved about outside the eye it may cause a piece of metal within to move, and it is thus used for diagnosis in doubtful cases. A deflection of the magnetic needle has also been observed to be caused by a piece of metal within the eye (Pooley, New York).

HEMORRHAGE INTO THE VITREOUS.

This is caused by the rupture of the vessels from injury or disease. The blood generally comes from the choroid, and the retina is detached and ruptured. Sudden obscuration of sight results. Small hemorrhages may be seen with the ophthalmoscope as dark-reddish masses against the red background. A very extensive one renders the vitreous so opaque that no reflex can be obtained from the fundus. The blood may be slowly absorbed, leaving only a few dark, floating opacities, and good vision be restored, especially in young persons; or the effects may be permanent and the eye be destroyed.

OPACITIES OF THE VITREOUS.

These result from inflammation or hemorrhage, and cause annoying disturbance of vision, appearing as black spots floating before the eye. They are of various shapes—dark dots, threads, and membranes. If the eye is illuminated from a distance of 12 inches by the ophthalmoscope, and then moved quickly in various directions, the opacities are easily seen floating about behind the lens. Sometimes the opacity is diffuse, making the fundus appear hazy and indistinct.

The *treatment* must be directed to the primary disease.

Muscæ volitantes (Lat. *musca,* a fly, and *volito,* to fly about), *myodescopia,* are floating spots often complained of. When they cannot be detected with the ophthalmoscope, they are not of a serious nature, and may occur in perfectly normal eyes. They appear usually as bright beads floating through the field when the patient views a bright clear surface—such as a white wall, sheet of paper, etc. They are due to shadows of the vitreous cells and they cannot be seen by the ophthalmoscope—which distinguishes them from pathological opacities. The only treatment is to quiet the patient's fears concerning them and correct the general health. Some of these cases develop opacities of the lens, and cataract afterward, but when a floating body cannot be seen by an experienced examiner with the ophthalmoscope, the patient's fears should be quieted.

HYALITIS: INFLAMMATION OF THE HYALOID, OR VITREOUS BODY.

This is usually secondary to inflammation of surrounding tissues. The changes are cell proliferation, fatty degeneration, connective-tissue formation, or suppuration, and they become evident by the opacity which they cause. The inflammation may be partial or complete. A new formation may be reabsorbed or remain permanently. The vitreous may degenerate and become fluid. This state is called *synchysis* (Gr. *σύν*, together, and *χύσις*, flowing), and may be diagnosticated, if there are opacities, by the rapidity and freedom of their movements. If cholesterin is present it appears as sparkling crystals, and the condition is called *synchysis scintillans* (Latin, *scintilla,* a spark). The fluid

vitreous is generally followed by shrinking and atrophy, with falling forward of the retina. A soft vitreous does not cause a soft globe if the tension is creased from other causes. The treatment of hyalitis is that required for the primary affection.

CYSTICERCUS.

Cysticerci have been found in the vitreous, generally projecting from the deeper tissues. They are of exceedingly rare occurrence in this country.

PERSISTENT HYALOID ARTERY.

This has been observed as a dark, withered thread running part or all of the way between the optic disc and the posterior pole of the lens.

THE ANTERIOR CHAMBER.

HYPOPYON (Gr. ὑπο, under, and πύος, pus) is a collection of pus or lymph at the bottom of the anterior chamber. The effusion may come from the cornea, iris, or ciliary body. It may be reabsorbed or, if not too tenacious, may be evacuated by incision at the lower edge of the cornea.

HYPEMIA (Gr. ὑπο, under, and αἱμα, blood) is an infusion of blood into the anterior chamber, and may result from a wound of the anterior part of the eye, or from a simple blow, without rupture of the coats, or, *very rarely,* it may be spontaneous. The best remedy is a compress bandage to keep the eye quiet and hasten absorption. Bathing the eye with warm water is also of benefit.

FOREIGN BODIES sometimes lodge in the anterior chamber. They should be removed always, if possible, through an incision in the cornea.

THE OPTIC NERVE.

OPTIC NEURITIS: INFLAMMATION OF THE OPTIC NERVE.

This is usually caused by extension of the inflammation from another part, or from pressure upon the nerve and obstruction to its circulation. It occurs in connection with abscess, periostitis, and tumors of the orbit; basilar meningitis; tumors of the brain; collection of fluid between the sheaths of the nerve, etc. Is called *ascending* or *descending,* according as it originates in the eye and extends upward along the nerve or *vice versa.* The ophthalmoscopic appearances are due to hyperemia, exudation, and swelling. In a marked case the disc looks red, opaque, and prominent, with the margins very indistinct, giving it a *woolly* appearance. The vessels are seen dipping into the swollen mass and partly obscured by it. The veins are distended, tortuous, and pulsating. This condition is called *engorged papilla, stauungspapilla* (Ger. *stauen,* to dam), or *choked disc.* The vision is impaired, but often less so than the appearance of the disc would indicate. The process usually ends in atrophy of the nerve and permanent loss of the sight. Neuritis is generally associated with retinitis, as *neuro-retinitis.*

The *treatment* varies with the cause, and this is sometimes beyond the reach of any remedies. Rest and colored glasses are always proper. Leeches, mercury, iodid and bromid of potash, and pilocarpin are of service in some cases.

ATROPHY OF THE OPTIC NERVE.

This results from infection and from other disturbances of innervation and nutrition, some of which are but little understood. It is seen with diseases of the brain and spinal cord; diseases of the orbit; pressure on the nerve; poison-

ing by quinin; syphilis, alcohol, and tobacco. The disc looks flat, opaque, and of a glistening white *(white atrophy)* or bluish-gray color *(gray atrophy)*, with its capillaries obliterated; it may present a shallow excavation with sloping edges, over which the vessels run without any abrupt curve. The retinal vessels may be small, the arteries appearing as fine threads. In some cases the veins are large and tortuous, as in inflammation. The vision is weakened, the field contracted and interrupted by scotomata, and color-perception may be impaired, especially in toxic amblyopia. In exceptional cases the disc presents the appearance of advanced atrophy, and vision remains perfect or nearly so.

The *treatment* is adapted to the cause and to the general conditions of the patient. Marked benefit is sometimes obtained from subcutaneous injections of strychnin, beginning with gr. $^1/_{60}$ and gradually increasing the dose until poisonous effect appears. The treatment is soon resumed with a nontoxic dose.

Syphilitic atrophy of the optic nerve is rarely recovered from. The condition producing atrophy is usually an inflammation of the nerve behind the ball: *retrobulbar neuritis*. The amblyopia occurring with appearances of atrophy in poisoning from the excessive use of tobacco or alcohol or from a mixture of them taken for some time in great excess is often recovered from under abstinence from alcohol and tobacco and the use of gradually increased doses of strychnin.

Tumors of the optic nerve have been observed, but are very rare.

OPAQUE OPTIC-NERVE FIBERS.

These appear when the medullary sheaths are retained for a certain distance, instead of being lost at the lamina

cribrosa as they normally should be. The most common form under which they appear is an irregular, white, striated opacity with feathery edges, projecting from the margin of the disc for a short distance into the retina. The retinal vessels may or may not be hidden by it. The disc and all other parts of the fundus look natural, and the vision is not impaired except by a slight enlargement of the normal blind spot. These facts serve to distinguish opaque fibers near the disc from an exudation in that region.

AMAUROSIS AND AMBLYOPIA.

AMAUROSIS (Gr. *αμαυροω*, to render obscure) and AMBLYOPIA (Gr. *αυβλύς*, dull, and *ὤψ*, eye) are names which were formerly much used to denote the various conditions of blindness before the diagnosis of ocular disease was as exact as it now is. As they convey no definite idea of the nature of the disease, they are objectionable wherever a more exact term can be used. The term *amblyopia* is still found convenient to designate certain conditions of impaired vision where no organic changes can be seen to account for them. The vision is often thus defective where the eye has been long disused, as in strabismus—*amblyopia from disuse,* or *exanopsia* (Gr. *ανα,* without, and *ὄψις*, vision); in anemia from severe illness or hemorrhage—*anemic amblyopia;* in alcoholism—*amblyopia potatorum* (Lat. *potator,* drinker); in uremia; lead poisoning; from excessive use of tobacco; from exposure to prolonged glare, as in snow-blindness and hemeralopia; from irritation of the fifth nerve, as in neuralgia; from excessive use of quinin.

So-called toxic amblyopiæ, from excessive use of tobacco or alcohol or both, have no very distinguishing marks in

the eye itself, except that a central color scotoma (for red and green) exists (Hutchinson, London). The temporal side of the optic disc is usually whiter than the remaining portion in this affection. Some authorities doubt the existence of a toxic amblyopia caused by tobacco alone, and insist that such alleged cases recover sight without abstaining from tobacco under treatment directed to the nutrition. Quinin amaurosis is distinguished by general regular limitation of the visual field, paleness of the optic papilla, and decrease in size of the vessels. When recovery occurs, the limitation of the visual field is likely to remain and the patient have only telescopic vision. It is a rare disease (Roosa, Knapp, Gruening, New York).

The treatment consists primarily in removing any supposed local or general cause. Hypodermic injections of strychnin are often of service. In some cases vision is restored; in others it deteriorates, and atrophy of the nerves becomes apparent.

GLAUCOMA.

GLAUCOMA (Gr. γλαυκος, green; from greenish reflex from the eye sometimes seen in this disease), or ARTHRITIC OPHTHALMIA, is a very dangerous disease. It occurs usually after middle age, and, if unchecked, it ends in incurable blindness. The essential feature is increase of the intraocular fluids, causing distension of the tunics and destructive pressure upon them. The exact etiology of glaucoma is not decided; it is supposed by some to be due to inflammation, by others to perversion of the nerve influence governing secretion. Rigidity of the sclera, interfering with perfect balance of the blood-supply, and narrowing of

the iris angle and the canal of Schlemm seem to play an important part. A large percentage of cases occur in hypermetropic eyes and in persons with an arthritic disposition. This disease usually attacks one eye first and the other subsequently. Generally there is a premonitory stage, of varying duration, and more or less marked by the following symptoms: Rapid increase of presbyopia; intermittent obscurations of sight; appearance of colored rings around a light; contraction of the visual field, *most on the nasal side;* slight increase of tension, and ciliary neuralgia.

ACUTE GLAUCOMA presents all the symptoms of severe internal inflammation. There are ciliary conjunctival congestion, photophobia, lacrymation, aching pain in the globe and over the head, with perhaps fever and vomiting; the cornea is cloudy; the iris pressed forward and the anterior chamber shallow; the pupil dilated and perhaps presenting greenish reflex; the aqueous and vitreous turbid; the tension is increased, even to stony hardness. The vision is much impaired. If the fundus can be seen, the arteries are found to pulsate spontaneously or from slight pressure on the globe; the veins are dilated, tortuous, and pulsating; and small hemorrhages may appear in the retina. If the tension has existed long enough, the optic disc is found cupped in a characteristic manner; the excavation extends to the margin of the disc, and its edges are abrupt, steep, and sometimes undermined; the nerve is of bluish-gray color, increasing in intensity toward the periphery; the retinal vessels appear distorted or interrupted where they pass over the edge of the cuplike excavations, if the object-lens (examining by the indirect method) is moved sideways, a parallax is obtained, the margin of the excavation appearing to move over its center "like

a frame over a picture." The severity and course of the disease are very variable. It may be very rapid, destroying the sight in a few hours—*glaucoma fulminans* (Lat. *fulmen*, lightning); or the acute symptoms may subside, leaving the eye more or less damaged, and then recur again and again until complete blindness ensues, the globe being hard as stone, the cornea dull and anesthetic, the anterior chamber shallow, the pupil dilated, and the lens opaque—*glaucoma absolutum*.

CHRONIC GLAUCOMA leads to the same results as the acute, but in a very insidious manner, the chief symptoms being increased tension, cupping of the disc, contraction of the field, and loss of vision. The affection may progress thus quietly for a time, and a sudden acute inflammatory attack then supervene. The use of atropin, homatropin, and perhaps other mydriatics in eyes predisposed to glaucoma sometimes, but very rarely, produces an outbreak of acute glaucoma (Hasket Derby).

SECONDARY GLAUCOMA is the name applied to glaucoma ensuing upon one of the ordinary injuries or inflammations of the eye.

TREATMENT.—The great remedy for acute glaucoma is iridectomy (first applied by von Graefe in 1856). It acts beneficially by permanently reducing the ocular tension, and, if performed in the early stages of the disease, is curative in a very large proportion of cases. As the disease advances and in the chronic form prospects of benefit from operation lessen. Trephining the sclera has been proposed—sclerotomy.

Sulphate of eserin has valuable remedial powers in glaucomatous conditions. In certain cases of acute and

chronic glaucoma it reduces the tension, improves the vision, and sometimes causes a temporary disappearance of all the bad symptoms. It may be tried preliminary to an operation, or where the latter is necessarily deferred, but cannot be regarded as a substitute for it, except in the chronic form, with subacute attacks, when it is often curative. If used in solution with oil (castor-oil preferred) very strong doses may be employed, 2 grains to the ounce, from four to six times in twenty-four hours. These instillations should be followed by fomentations with water for ten minutes or so (Panas, twentieth century).

Paracentesis of the cornea may also be done to reduce the tension where, for any reason, the iridectomy has to be delayed. Sperino (Italy, nineteenth century) recommends treatment of the disease by repeated paracenteses.

Sclerotomy has been proposed (de Wecker, 1867) as a substitute for iridectomy in cases where iridectomy is very difficult or dangerous, or where it cannot be performed at all. It is specially recommended in absolute glaucoma where an operation is done merely to relieve pain. The operation consists in making an incision in the sclera near the margin of the cornea. Posterior sclerotomy, the incision being behind the lens, is also performed. The present writers favor the use of eserin in an oily solution in chronic cases and in cases that do not appear to be fit for an operation. Pilocarpin in 1-per-cent. solution is also used. Enucleation is practiced in cases of absolute glaucoma attended by pain which is not relieved by any other means.

In 1898 it was suggested by Abadie that a relief from otherwise incurable glaucoma might be obtained by a section of the cervical sympathetic. The first operation of resec-

tion of the cervical sympathetic was performed by Jonnesco. Since that time it has been performed by Webster, Bull, and Weeks, of New York, and others. It is a surgical operation, requiring considerable experience, and is usually performed by general surgeons, at the request of ophthalmologists. It is not suitable for acute cases, and is a last resort when other therapeutic measures have failed. By its employment cases are reported where the pupil became permanently smaller, the tension reduced, and even the field of vision widened. Ptosis may result, and even the vocal apparatus may be affected for a time. It is the opinion of the writers that the operation has not, as yet, been successful enough to warrant its recommendation in other than very exceptional cases.

Sympathetic Ophthalmia.

This is an extremely dangerous inflammation, attacking the sound eye after disease or injury of its fellow, and is propagated either by infection through the lymph channels from the injured eye (Deutschmann) or through the medium of the ciliary nerves. Since a specific bacillus has not yet been found, this question remains unsettled. The conditions most apt to cause it are injuries in the ciliary region, foreign bodies within the globe, and inflammations involving the ciliary body. The period of occurrence is variable. It may appear shortly after injury (two weeks) or not until many years have elapsed, the injured eye having, perhaps, meanwhile atrophied to a shriveled stump. The usual length of time is from four to eight weeks after the injury. The danger of it cannot be considered as past so long as the injured eye remains, especially if this shows any tenderness or irritation. The disease may come on very insidiously, and

is often unnoticed until beyond hope of aid. There is a condition called *sympathetic irritation* which is quite different from sympathetic ophthalmia, but is regarded by many as a premonitory stage of it. In this condition the eye is irritable and perhaps slightly injected; there is photophobia, lacrymation, and neuralgic pain; the power of accommodation is diminished and the eye is quickly fatigued by fine work. These symptoms may recur repeatedly and pass off, leaving no organic changes, and they cease completely after the other eye is removed. *Sympathetic inflammation* attacks the iris, ciliary body, choroid, retina, and vitreous, the extent to which these different structures are involved varying in different cases. The tendency is toward rapid plastic effusion, which glues the different tissues together and destroys them. The iris is bound to the lens and becomes degenerated and rotten. It may be drawn backward by the adhesions or bulged forward by exudations behind it. Masses of lymph may fill the pupil or be seen floating in the vitreous. There is ciliary congestion, photophobia, lacrymation, with rapid loss of sight. The pain may be severe or absent, but there is always tenderness of the ciliary region and at the insertion of the superior rectus muscle. The tension is increased at first, but reduced later as the eye degenerates.

TREATMENT.—This must be mainly preventive, as little can be done when the disease is once established. A blind eye from which there is the slightest risk of sympathetic ophthalmia is always better removed, especially if the patient lives some distance from surgical aid. If the injured eye possesses some sight, it may be left, but should be closely watched, and enucleated the moment it sets up sympathetic irritation. If true sympathetic inflammation is

established, the offending eye should be at once removed if the injured eye is sightless, but the chances of benefit are then small. If the injured eye has considerable sight it should not be removed, as it may and often does retain more sight than the other. Complete rest of eye and protection from light, strong solution of atropin frequently applied, inunctions of mercury, tonics, and good food are all important in the treatment.

OPTICO-CILIARY NEUROTOMY.[1]

This is an operation which has been developed since 1867 as a substitute for enucleation, in sympathetic ophthalmia, and in other cases where it is specially desired to save the eyeball. It consists in the division of the optic and ciliary nerves by a pair of curved scissors passed backward through an opening made in the conjunctiva. It is customary to divide one of the recti muscles to make room for the dissection (although this is not necessary) and its cut ends are reunited by sutures after the nerves have been divided. The operation has not proved to be a good substitute for enucleation. As matters now stand, the consensus of professional opinion is still for enucleation as the only means of preventing sympathetic ophthalmia.

METHOD OF PERFORMING ENUCLEATION.

The technique of the operation of enucleation has been changed by some surgeons, although many perform the operation as has been described. Sutures are inserted in the conjunctiva (Argyll Robertson). The divided ends of the recti

[1] Von Graefe, Boucheron, and Schoeler.

muscles are sutured to each other, after which the conjunctiva from above and below is brought over the muscle stump and fastened with a continuous suture (Suker). Another method is to secure each rectus tendon with a catgut suture and to make a slit in the conjunctiva over each muscle in which the divided conjunctiva is fastened. The conjunctiva is then brought together with a continuous suture (Schmidt-Rimpler). Still another method is to pinch up a narrow, horizontal fold of the conjunctiva over the rectus, so as to include the connective tissue and muscle lying beneath, then carrying a black silk suture through these structures with a curved needle. The other straight muscles are attached in a similar manner, after which the enucleation is carried out in the usual way, and the conjunctival aperture closed with the sutures.

It is claimed for these operations that the movement of the conjunctival bed is increased by them over that which is secured by an ordinary enucleation. The present writers, however, think that, with a properly adjusted Snellen artificial eye, this alleged advantage is, at any rate, not required. The Mules operation, soon to be described, is the most feasible one of any of the operations practiced in place of enucleation.

Accidents.—Severe bleeding may occur after enucleation, but this is very rare if the stump be carefully cleansed, the orbit packed with strip gauze, a good, firm bandage be applied, and a thick layer of gauze placed immediately over the lid.

When there is a fistula in the cornea, or when the corneal walls have been very much thinned, it is very difficult to remove the eyeball without causing a rupture and

prolapse of some of the contents of the globe. In case of rupture of the globe, a stout ligature, passed through the sclera and tied, furnishes a good attachment by which the globe can be kept on the stretch and the optic nerve properly divided.

Substitutes for the Operation of Enucleation.—One of the most celebrated of these is Mules's. The operation is performed in the following manner: The speculum is introduced as usual, and the conjunctiva dissected from the corneo-scleral attachments, in all directions, back to the equator of the ball, without disturbing the muscles. The cornea and 1 millimeter of the scleral margin are removed. The contents of the globe are then evacuated with a small scoop. Pains are taken to make the evacuation complete and leave a perfectly clean, white sclera. The hemorrhage is controlled by sponging with sterilized gauze, and by irrigation with a tepid solution of bichlorid of mercury, 1 to 5000. A small glass or gold sphere, which can be introduced within the scleral cup without difficulty, is then placed in, the sclera being slit up vertically for about 4 millimeters at the upper and lower margins. The sclera is then stitched vertically, the conjunctiva horizontally, and an antiseptic dressing applied. Considerable reaction is apt to follow this operation, which may, to some extent, be controlled by the continuous application of iced cloths. Catgut and silk sutures may be employed. The authors do not recommend this operation in preference to the one already described, but it has many advocates, in appropriate cases.

Another method is to insert a gold or glass sphere within Tenon's capsule, after enucleation in the usual way. The capsule and sheath are next sutured over the artificial

globe, the tendons of the ocular muscles having previously been secured. Lately paraffin has been used to fill the scleral cavity, instead of the glass ball, and the sclerotic and conjunctiva stitched over it to retain it. In malignant disease the contents of the eyeball must be removed by *exenteration,* which means simply that the entire contents of the orbit are removed.

INSERTION OF AN ARTIFICIAL EYE.

A temporary one should be used at the earliest possible moment after the operation, which is usually in about seven days. The artificial eye keeps the lid in proper position, facilitates the rapid healing, and may be inserted as soon as the swelling has sufficiently subsided properly to allow it.

THE MUSCLES.

STRABISMUS, OR SQUINT.

(Gr. *στραβισω*, to squint.)

This is a loss of proper balance of the ocular muscles, so that, when the visual line of one eye is fixed upon an object, that of the other deviates more or less from it. It is caused by anything which develops preponderance of power or causes weakness in a muscle, either directly or indirectly. It may arise from some refractive anomaly; from anything which prevents binocular vision (cataract, corneal opacity), in which case the excluded eye yields passively to the muscle which happens to be the strongest; or from paralysis of muscles (paralytic squint). The chief forms are *convergent strabismus* (the eye deviating inward) and *divergent strabismus* (the eye deviating outward). An upward squint is called

strabismus sursumvergens; a downward squint, *strabismus deorsumvergens.* Squint is confined to one eye only in cases of paralysis. Squint from errors of refraction (functional strabismus) is always bilateral, although one eye usually squints habitually, without good fixation. Strabismus should therefore be divided into two great varieties—functional and paralytic. To bring out the strabismus of the usually properly adjusted eye cover the eye with a shade, while fixation is secured with the usually squinting eye; on quickly removing the hand from the front of the other eye it will be seen that it has been squinting while the other was fixed. The range of motion of the squinting eye may be curtailed or it may be as great as ever.

The deviation of the squinting eye when the sound eye is fixed upon an object is the *primary deviation.* The movement which the sound eye makes when covered with the hand while the squinting eye is made to fix its visual line upon an object is the *secondary deviation.* All squint, except that due to paralysis of one or more of the ocular muscles, is concomitant, so that this descriptive adjective, widely used, is unnecessary. Strabismus is measured by the distance between two points marked on the lower lid to correspond with the position of the center of the pupil of the squinting eye (1) when its visual line is fixed upon an object, and (2) when the visual line of the other eye fixes the object. Instruments for noting this distance are called *strabismometers.* The amount of the squint may be measured with the perimeter and a candle. When the squint is generally monolateral the squinting eye is frequently amblyopic, from the habit the patient acquires of unconsciously suppressing its retinal image, so as to be rid of the diplopia (?). Am-

blyopia is caused by this suppression when continued for a long time (amblyopia exanopsia).

CONVERGENT STRABISMUS.

Convergent, or internal, strabismus is connected with hypermetropia in the great majority of cases. In hypermetropia the accommodation is constantly called into excessive action, and this is always associated with increased convergence. In attempting to increase accommodation, so as to gain clear vision, one eye squints inward. At first the squint may be *periodic,* appearing only when close work is undertaken, but it soon becomes permanent. Convergent squint is most frequent in moderate degrees of hypermetropia, where the sight is markedly improved by these increased efforts of the ciliary and interni muscles. Very rarely it occurs in high degrees of myopia, where the eyes are much used at fine work, and the internal recti become contracted from excessive use. It may also occur from division or paralysis of the external rectus.

DIVERGENT STRABISMUS.

This form of squint is most frequently accompanied by myopia. In myopia strong convergence is often required, yet it is difficult from the shape of the eyeball, which is a long eyeball and assumes the direction of the bony orbit, which is outward; and the internal recti become strained and weakened, and thus allow the eye to deviate outward. Also when one eye is blind or very defective, the impulse to binocular vision is lost, the internal rectus grows weak, and divergence occurs. It may also be produced by division, paralysis, or defective innervation of the opposite muscle.

Treatment for functional squint should be:—

1. Correction of the refractive error under the influence of a mydriatic.

2. Orthoptic treatment—that is, forced use of the squinting eye by covering the straight eye with a pad; the use of stereoscopic exercises; in convergent squint the use of atropin in the eyes twice a day for a month at a time, then a rest of a month. These orthoptic exercises should be kept up as long as the squint lessens or is cured. About 33 per cent. of all cases are cured in this way alone. (A. E. Davis.)

3. Operation. This consists in dividing the tendons of the contracted muscles. This weakens the muscle by allowing its tendon to recede and acquire a new insertion farther back on the sclerotic, and so, indirectly, strengthens the opposite muscle. After the operation the glasses given before the operation should be worn to correct the refraction and prevent recurrence of the squint.

Since strabismus is a bilateral affection, the procedures for the relief should be bilateral. The contraction of the muscles, which is spastic in character, is first treated by stretching the muscle on the strabismus hook with which it is taken up, after which it is separated from its attachment to the eyeball, with the scissors, at the same sitting (Panas).

PARALYTIC STRABISMUS.

Paralysis of the Nerve Supplying the Muscles.—One or more of the nerves may be affected, and paralysis may be total or partial (paresis). A fixed squint may result, or the trouble may be difficult to detect, being only manifest by diplopia and impaired mobility in a certain direction.

The causes of paralysis are often obscure. It may result from pressure on the nerve; from cerebral or orbital disease; from syphilis, rheumatism, and so forth, syphilis being the most frequent cause. The diplopia generally shows which muscle is affected, as a certain form of it accompanies each different paralysis. If paralytic squint is present, it is distinguished from the functional form by the fact that the secondary deviation is greater than the primary, instead of being just equal to it. This results from the fact that deficient innervations of the paralyzed muscle demands a greater effort than normal to bring the eye into a given position; and this, being reflected upon the healthy muscle of the other eye, causes a disproportionate secondary deviation.

PARALYSIS OF THE THIRD NERVE.

The paralysis of the third nerve is the most frequent. It may be complete or partial, and affect one or all of the branches. In complete paralysis the upper lid droops (ptosis) and the eyeball is left to the control of the external rectus and superior oblique muscles, which draw it outward and a little downward—a movement caused by the superior, inferior, and internal recti and inferior oblique being absent. The pupil is dilated and immovable, and accommodation is lost. There is crossed diplopia. In partial paralysis all of the above symptoms may exist in a lesser degree, or only some filaments of the nerve may be affected, and the loss of power be thus confined to one or two muscles. If the branch to the internal rectus is paralyzed, there is deficient mobility inward and crossed horizontal diplopia, the images being on the same level and parallel. If the superior rectus is paralyzed, there is impaired motion upward and inward,

and diplopia occurs above the horizontal line, the images being crossed and diverging at the top, the false one standing above the true. If the inferior rectus is paralyzed, there is impaired motion downward and inward, and diplopia appears below the horizontal line. The images are crossed, the false one standing below the true one, and they converge at the top.

Paralysis of the fourth nerve affects the superior oblique muscle. There is impaired motion downward and outward, and homonymous diplopia below the horizontal line. The images converge at the top and the false one stands below the true.

Paralysis of sixth nerve affects the external rectus. There is impaired motion outward and homonymous horizontal diplopia, the images being on the same level and parallel.

In paralysis of the ocular muscles, the patient usually rotates or tilts the head in the direction of the paralyzed muscle—*e.g.*, if the right external rectus is paralyzed, the patient will carry his head to the right.

The *treatment* of paralysis must depend on the cause. Electricity is sometimes of use. To relieve the patient from the diplopia the affected eye may be covered with a shade, or a prism worn to fuse the images if the deviation is not too wide. If all treatment fails, division of the opposite muscle and advancement of the affected one may be performed.

In a large percentage of cases, variously estimated from 40 to 80, syphilis is the cause of paralysis of the third, fourth, and sixth nerves. A very careful investigation should be made as to this point. If syphilitic infection has occurred, or has probably occurred, the patient should have the benefit of the doubt by a long and thorough antisyphilitic treatment.

NYSTAGMUS.

(Gr. νυσταγμός, a nodding.)

This is marked by involuntary, spasmodic oscillations of the eyeball. The movements are generally horizontal and in both eyes. They may be periodical or continuous, and increased by general excitement or accommodative efforts. The vision is much confused, and the patient often improves it by inclining the head in the direction opposite to that in which the eyeball oscillates. Nystagmus generally appears in infancy, in cases where clear vision is difficult (on account of corneal opacities, refractive defects, cataract, etc.), the impulse to proper innervation being thus lessened. It is also seen in coal-miners, probably from undue strain.

The *treatment* is chiefly prophylactic, as little can be done after the condition is established. Whatever improves vision tends to improve the nystagmus. That found in coal-miners or developed late in life is much more amenable to treatment than that occurring in infancy. Nystagmus is sometimes one of the early symptoms of serious cerebral or cerebellar abscess, as well as of other forms of disease of the brain and medulla.

INSUFFICIENCY OF THE INTERNAL RECTI.

This defect occurs generally in high degrees of myopia, which produces increased convergence and overtaxing of the muscles. It also occurs in general muscular debility. It causes marked asthenopia when fine work is attempted. The tests for insufficiency have been given on a preceding page. The power of the recti interni and externi may be tested for near and distant vision by finding what

prisms they can overcome. The power of the externi is called the *abduction,* or *facultative, divergence.* That of the interni, *adduction,* or *facultative, convergence.* Muscular asthenopia, as compared with accommodative asthenopia, is very rare. Much that has been assumed to be so is due to astigmatism and other errors of refraction, or at least becomes harmless when the co-existing astigmatism is corrected. It is important fully to examine as to the refraction, especially as to astigmatism, for it is the error that is the chief cause of weak ocular muscles. A general irregular action of the ocular muscles is sometimes one of the early symptoms of locomotor ataxia. As a matter of routine, the muscles should be examined as to adduction, abduction, sursumduction, etc., so as to detect marked insufficiencies and to make a complete examination.

Reflex Symptoms or Diseases from Insufficiency of the Ocular Muscles and Errors of Refraction.—Since 1874 (Stevens, New York) and 1884 (Ranney),[1] it has been claimed by several writers that chorea, epilepsy, and general disease of various kinds occurred in a large percentage of cases from uncorrected errors of refraction or insufficiency of the ocular muscles. After much discussion these views have not been generally accepted by the profession. Reflex affections from the eyes, except in very rare and exceptional cases, are limited to the head. When these reflex symptoms occur, the eyes themselves, the point of origin of the irritation, will give some evidence of the trouble. It is not usually latent.

---

[1] **Also G. M. Gould, 1902.**

Treatment.—Correction of the error of refraction, especially of astigmatism, is the most important factor. Prisms were formerly generally prescribed, but it is doubtful if they are of value, except as a means of suggestive treatment. The division of the muscles is to be undertaken only for the correction of strabismus or manifest diplopia. Even migraine occurring in patients with refractive errors does not cease on the proper adjustment of glasses for refractive error, important as it is that such errors should be corrected when possible.

THE EYELIDS.

The eyelids are subject to the same affections as other parts of the general integument, such as *hyperemia, edema, inflammation and abscess, erysipelas, acne, herpes, eczema, warts, nevi, syphilitic ulcers, cancer,* and so forth. These require the same treatment here as elsewhere. The special danger to be guarded against is that of inflammatory and cicatricial changes, which easily produce deformity of the lids, with all its evil results.

BLEPHARITIS MARGINALIS OR CILIARIS: TINEA TARSI: OPHTHALMIA TARSI.

(Gr. βλεφαρον, eyelid.)

This is essentially an inflammation of the hair-follicles along the edge of the lid, but other structures soon become involved also. The edge of the lid is at first hyperemic, and later swollen, smooth, and glossy. The discharges form small, yellow scabs, which glue the lashes together in little bundles. Little pustules appear about the roots of the lashes, which may leave small ulcerations and fissures. The hairs fall out, and

the new growth is apt to be thin, stunted, and misdirected. If the disease progresses, the edge of the lid may become hypertrophied and callous, constituting *tylosis* (Gr. τύλη, callus); and it may also be everted. Hairs may cease to grow altogether, leaving the lid bald—*madarosis* (Gr. μαδαρος, bald). The disease occurs in the course of other inflammations; from exposure to irritating influences; in general debility, from whatever cause; and is most common among poor and dirty classes. It is often associated with some refractive anomaly, and disappears when this is corrected (Roosa). If it be dependent upon a refractive error, this may be demonstrated by the use of atropin or other cycloplegic, which will at once lessen the symptoms until glasses can be adjusted. It is very obstinate and recurrent.

Treatment.—Cleanliness is of first importance. The crusts should be washed away several times a day with warm water or an alkaline lotion such as 10 grains of soda bicarbonate to 1 ounce of water. After cleansing, some astringent should be applied. Ointments of the yellow and red oxids of mercury, in the strength of 1 grain of yellow or $^1/_2$ grain of red to 1 drachm of benzoated lard or the like are the best. Solutions of nitrate of silver applied to the roots of the lashes are very useful. The refraction should always be carefully tested and corrected if at fault.

HORDEOLUM (Lat. *hordeolus,* a stye), or STYE, is a boil affecting the connective tissue near the edge of the lid. Sometimes several appear at once, and there is often a succession of them. They cause great swelling of the lid and considerable pain. When suppuration and sloughing occur, some of the follicles are liable to be destroyed, and cicatricial deformity may be left.

Treatment.—Fomentations of water should be used until pus forms, when the tumor should be firmly grasped between the thumb and finger, and opened by an incision parallel with the edge of the lid. The general health almost always requires attention, for styes constitute a local infection for which the ground is prepared by impaired nutrition. Styes sometimes seem to be *aborted,* if they are touched, when first noticed, by nitrate of silver or an astringent ointment applied. Sometimes it is useful to incise them when they first appear. It may be said, once for all, that the frequent occurrence of styes, chalazia, or any affection of the lids should suggest careful examination as to the refraction and the general health.

CHALAZION (Gr. χαλασα, hail), or TARSAL CYST, is occasioned by obstruction of the orifice of a sebaceous gland (Meibomian) and retention of secretion. A tumor is thus formed in the cartilage, generally about the size of a pea, and situated near the conjunctival surface, so that it becomes prominent when the lid is everted. The overlying skin is usually of natural color and freely movable. If inflammation has occurred, the cyst will contain pus; otherwise it will be filled with gelatinous, fatty material. The name is applied also to chronic stye.

Treatment.—Evacuate the cyst through the conjunctiva or skin, according to circumstances. A free incision is made into the tumor, and if the contents are purulent they readily escape. A curette is then used to empty the sac, and its walls are cauterized or irritated so as to obliterate it. Or the entire sac may be carefully dissected out.

DEFORMITIES OF THE LIDS.

The lids are subject to several deformities produced by chronic inflammation, and by ulcers, burns, and injuries, which cause loss of tissue and cicatricial contractions.

TRICHIASIS (Gr. θριξ, hair) is an inversion of the lashes so that they rub against the eyeball—a consequence usually of trachoma.

DISTICHIASIS (Gr. δίστιχια, a double row) is the same affection, except that there appear to be two rows of lashes. If the inversion has lasted long, the cilia will be bleached by constant soaking in the secretions and may be easily overlooked.

ENTROPION (Gr. ἐντροπη, a turning toward) is a turning in of the free edge of the lid against the globe. It is sometimes spasmodic, from spasm of the orbicularis muscle.

ECTROPION (Gr. ἐκτροπη, a turning from) is an eversion of the lid, exposing its conjunctival surface.

All the above-named conditions keep the eye in a state of constant irritation and discomfort. They are most commonly seen in the upper lid. A variety of operations are performed for their cure, a choice of which is determined by the requirements of each case. In entropion temporary relief is obtained by pulling out the inverted lashes by fine forceps (epilation), but they soon grow again. Mild cases may be relieved by removing an elliptical piece of the skin of the upper lid, and uniting the edges of the wound by sutures. The shortening of the skin thus produced tends to draw the edge of the lid outward and away from the globe. For bad cases the operation of Jaesche and Arlt (Vienna, nineteenth century), or one of its modifications, is very com-

monly performed. The operation of "scalping," sometimes done in inveterate cases, consists in dissecting off all the cilia with their bulbs, leaving the lids permanently bald. Many cases of ectropion result from injury and cicatricial contraction requiring plastic operations. (See "Operations" for description of the various plastic operations.)

Ptosis (Gr. πτωσις, falling) is a drooping of the upper lid, either partial or complete. It is caused by injury of the levator muscle, swelling and increased weight of the lid from inflammation, or by paralysis of the third nerve. It is sometimes seen in old people from great relaxation of the tissues. Rarely it is congenital, and may be due to absence of the levator muscle.

There are various operations that are often of essential use; that of Panas, modified by Van Fleet (New York), is one of the best.

Van Fleet's modification of Panas's operation consists in dissecting a quadrilateral flap of skin from the upper lid, leaving it attached at the lower border, the flap is about $^3/_4$ inch wide and about $^1/_2$ inch in the vertical direction (extending, as it does, from the fold at the upper edge of the cartilage to the lower border of the lid). The effect of the operation may be increased or diminished by making this flap shorter or longer. An incision is now made in a horizontal direction above the upper edge of the orbit (the eyebrows having been shaved off) through the skin and muscle down to the bone, about $1\,^1/_2$ inches long. The bridge of skin between this incision and the upper edge of the incision made for the tarsal flap is now dissected up from the underlying muscle. The upper edge of the skin flap from the upper lid is now drawn up under this bridge of skin and

attached to the occipito-frontalis muscle and skin of the upper edge of the incision in the brow, and later the upper incision is closed with sutures and the eye dressed. Although the epithelial skin surface of the flap is brought in touch with the raw under surface of the bridge of skin, they unite after some weeks, and the cosmetic effect is usually good.

Gillet de Grandmont's operation (practiced first in this country by Dr. Gruening) consists in cutting an elliptical piece out of the upper lid, muscle, cartilage, and conjunctiva and bringing the edges of cartilage and conjunctiva together with sutures. The width of the piece to be removed depends on the elevation of the lid desired. If there is 4 millimeters of ptosis, 4 millimeters of the cartilage should be removed. Catgut sutures (No. 00) are used and the skin is not sutured as it is brought in perfect apposition when the cartilage is brought together. Dr. Gruening uses silk instead of catgut.

PARALYSIS OF THE ORBICULARIS MUSCLE is a result of paralysis of the *portio dura* of the seventh nerve. The lids cannot be completely closed, and the patient thus has a peculiar staring appearance called *lagophthalmos* (Gr. λαγως, a hare, and ὀφθαλμός, eye). The lower lid falls away from the globe so that tears run over, and the eye suffers from constant exposure to external irritants.

BLEPHAROSPASM.—A spasmodic contraction of the orbicularis, so that the lids are firmly pressed together against the globe, occurs where photophobia is marked, and presents all grades of severity. It is reflex from irritation of the fifth nerve, and occurs in neuralgia of its branches; in inflammation of the conjunctiva or cornea; from foreign bodies; in hyperesthesia of the retina, errors of refraction, and so forth.

The *treatment* consists primarily in removing the cause. Other remedies are hypodermic injections of morphin; immersion of the face in cold water; canthoplasty; conium given until poisonous effect appears, and so forth. In neuralgia of the fifth nerve, division of the affected nerve is sometimes practiced.

NICTITATION (Lat. *nictitatio,* winking). A spasmodic contraction of the orbicularis, shown by frequent twitching and blinking of the lids, is seen generally in weak and nervous patients. Nervous exhaustion is probably the chief cause. It is allied to chorea. In recent cases in young children it is relieved by conium.

ECCHYMOSIS of the lids is effusion of blood into the cellular tissue, producing "black eye." The blood undergoes discoloration before it is absorbed, turning green, yellow, etc. To hasten absorption, hot applications, stimulating lotions, and the compress bandage are useful.

INCISED AND PUNCTURED WOUNDS AND BURNS should be very carefully dressed, especially if they involve the cartilage, lest deformity of the lids result from healing.

EPICANTHUS (Gr. ἐπί, upon, and κανθός, angle of the eye).—A congenital malformation in which a crescentic fold of skin passes from the nose to the eyelids, overlapping the inner canthus more or less. Removal of a piece of the integument of the bridge of the nose will often much improve the condition.

COLOBOMA.—Congenital fissure of the lid is sometimes associated with coloboma of the iris and the choroid, harelip, cleft palate, and so forth. A plastic operation is usually of service.

Ephidrosis is an excessive secretion of the sweat-glands of the lids. It causes itching and biting sensations and irritations and inflammation of the skin and of the conjunctiva. It is difficult of cure.

Chromidrosis is a dark-blue or black discoloration of the skin of the lids, appearing suddenly, and capable of being washed off with glycerin or water. It is seen chiefly in hysterical females, and is supposed by some authors to be always due to simulation.

Xanthelasma, xanthoma, or vitiligoidea appears as peculiar yellow patches, usually situated on the skin of the eyelids, and most often the upper lid, near the inner canthus. Sometimes the patch is raised a little, sometimes not. The disease is most common in females and in those of middle age. Dissection shows that the connective-tissue cells of the parts are filled with fat. By some there is thought to be a connection between xanthoma and liver trouble.

Excision of the patches is the proper treatment. Chromic acid fused on a sharp-pointed probe and inserted at several points under the epithelium is said to effect a cure without leaving any scar (McCoy).

The Lacrymal Apparatus.

LACRYMAL CATARRH.

Stillicidium lacrymarum (Lat. *stillicidium,* dripping, and *lacryma,* tear), epiphora (Gr. ἐπί, upon, and φερω, to bring?), or watery eye, is a condition common to nearly all lacrymal diseases. It is caused by any impediment to the efflux of tears through the tear-passages, whether a simple

displacement of the puncta so that tears cannot enter them, or an obstruction of canaliculi, sac, or ducts. The tears accumulate at the inner angle of the eye and flow over the cheek, causing continual irritation and annoyance. Unless the condition depends on some cause which can otherwise be removed, it must be remedied by an operation. The method of opening the canaliculi and probing the nasal ducts has already been given. Syphilis plays an important part in the causation of lacrymal diseases, and should always be looked for.

The nose should be treated, as catarrhal conditions are often the cause of stoppage of the lacrymo-nasal duct at its lower end.

DACRYOCYSTITIS (Gr. *δακρυον*, tear, and *κυστις*, bladder), ACUTE INFLAMMATION OF THE LACRYMAL SAC OR ABSCESS OF THE SAC, may result from conjunctivitis, nasal catarrh, exposure, injury, chronic disease of the tear-passages, and so forth. It is attended by great pain, tenderness, redness, and puffy swelling over the sac and extending to the lids. If disease progresses, the skin becomes thinned and the abscess bursts through it.

Treatment.—This consists in opening of the canaliculus so as to give free exit for pus and prevent perforation through the skin. If the latter is imminent, a free incision should be made through the skin into the sac, and kept open until the abscess is completely drained. If perforation has already occurred, the canaliculus should be slit up and probes passed to open the natural channels so as to allow the external opening to heal. No scar results from a free incision into the lacrymal sac when such a one is necessary.

Chronic Inflammation of the Sac: Blennorrhea of the Sac: Mucocele (Gr. μυκος, mucus, and κηλη, tumor).—An insidious chronic inflammation of the sac, resulting from acute or chronic inflammations of the conjunctiva or nose, malposition of the puncta, etc., and nearly always associated with strictures of the lacrymal passages. These are most frequent at the junction of the canaliculi with the sac, but may occur at any other point. There is constant epiphora and irritability of the eye. The swelling of the sac varies, and, if it is pressed upon, viscid mucus oozes out through the puncta.

The *treatment* consists in opening the canaliculi and relieving the strictures of the passages by probing or incision. Astringent fluids injected into the sac sometimes are of benefit. Treatment is moderately successful, but must often be very protracted, and some cases never recover. For extremely troublesome cases, with caries of the bones, an operation to obliterate the sac should be performed.

Fistula of the lacrymal sac is an external opening through the skin, left generally by inflammation. It is often associated with strictures of the passages and caries. The natural communication should be restored through the nose by the methods already indicated—incision of the canaliculus and probing the nasal duct.

Diseases of the lacrymal gland are very rare. They comprise *inflammation of the gland; dacryo-adenitis,* usually chronic; *cysts of the gland, dacryops* (Gr. δακρυον, tear, and ὤψ, eye), which is usually due to a closure of the excretory ducts and distension from secretion above; *fistula of the gland,* generally resulting from abscess, dacryops, or

injury; and *cancer*. Extirpation of the gland is sometimes performed. Cases of severe orbital cellulitis, with pressure upon the optic nerve, ending in atrophy and blindness, as a result of lacrymal blennorrhea, occasionally occur. The surgeon should always in lacrymal cases give careful consideration to the conditions of the adjacent sinuses and the maxillary antrum.

CHAPTER IV.

ANOMALIES OF REFRACTION AND ACCOMMODATION.

THE REFRACTION of an eye is its faculty of bringing parallel rays of light to a focus upon its retina without any effort of accommodation, and depends on the form of the globe and its refractive media.

The ACCOMMODATION of an eye is its power of adjusting itself for vision at different distances—that is, for rays of different degrees of divergence. The nature of accommodation and the method of measuring it have already been given.

EMMETROPIA (Gr. ἐν, within; μέτρον, measure; and ὤψ, eye).—That state of refraction in which parallel rays are brought to a focus upon the retina when eye is at rest.

MYOPIA (Gr. μυον, to wink, and ὤψ, eye).—From the habit such patients have of squeezing the eyelids together to see more distinctly. That state of refraction in which, with the eye at rest, parallel rays are focused *in front* of the retina, only divergent rays being united upon the latter.

HYPERMETROPIA (Gr. ὑπερ, beyond; μέτρον, measure; and ὤψ, eye).—That state of refraction in which, with the eye at rest, parallel rays are focused *behind* the retina, only convergent rays being united upon the latter.

ASTIGMATISM (Gr. ἀ, privative, and στιγμα, a point).—That state of refraction in which, with the eye at rest, rays from a point are not reunited in a point.

AMETROPIA (Gr. ἀ, privative; μέτρον, measure; and ὤψ, eye).—The name applied to all refractive conditions which deviate from emmetropia.

ASTHENOPIA (Gr. ασθενης, weak, and ὤψ, eye), or WEAK SIGHT, is the name for a group of symptoms often seen in the various refractive defects or as a result of general disease or debility. After reading, writing, and so forth, for any length of time, the letters become blurred, and run into one another, the eyes grow red, watery, hot, painful, or fatigued. The symptoms vanish when the work is laid aside, to recur again as often as it is resumed. This may continue indefinitely until the cause is removed. Asthenopia most frequently results from an error of refraction and is relieved by correction of the error, which is usually astigmatism or hypermetropia or the two combined. There is, however, a form of asthenopia due to neurotic conditions or to uterine disease which cannot be corrected except by constitutional care. But this form is not always curable.

MYOPIA.

This is caused generally by too great length of the optic axis; exceptionally by too high refractive power of the lens or cornea. Spasm of accommodation causes a *false* myopia. Myopia is sometimes hereditary or congenital; it may be acquired from prolonged straining at fine work. It is stationary or progressive; in the former case it is generally of low degree and causes little annoyance; high grades are apt to be progressive, and, if so, are associated with marked irritation and asthenopia. The far point of distinct vision lies nearer the eye than it should. Beyond this point all objects appear indistinct. The far point expresses the degree of the M.; for instance, if the patient cannot see clearly beyond 24 inches he is said to have M. $^1/_{24}$, or, expressed in diopters, 1.50 D. To see objects distinctly the rays, before

entering his eye, must be made to diverge as if they came from a point 24 inches away, as thus only can they be united on his retina. This is done by a concave glass of 24-inch focus (about 1.50 D). With the ophthalmoscope, the details of the fundus of a highly myopic eye can be seen by the direct method at some distance away; and, if the head is moved to one side, the objects of the fundus are seen to move in contrary direction. This is due to the fact that, in such cases, an aërial image of the fundus is formed by the refractive media of the eye itself at a distance corresponding to the M.; for example, in M. $^1/_3$ (12 D), at 3 inches in front of the eye. To get a clear view of the fundus in the erect image, a certain concave glass must be used behind the mirror. The focal length of this glass, *plus* its distance from the nodal point of the observed eye, equals the M. By the indirect method the disc and vessels appear smaller than in emmetropia.

Posterior staphyloma is often seen around the disc, and is called the *myopic arc,* or *crescent.* The glass used behind the ophthalmoscope to get a clear view of the fundus in myopia or hypermetropia represents the degree of the refractive defect *practically,* because it is held at about the same distance from the eye as would be the correcting spectacles. But to estimate the refraction *accurately,* we must consider the distance between the glass and the nodal point of the observed eye. In myopia the correcting glass is stronger, and in hypermetropia weaker, than it would be if it could be placed at the nodal point. Hence, to obtain the exact degree of the myopia we add to the denominator of the fraction representing the focal length of the correcting lens its distance from the nodal point. If the fundus is seen clearly through

a — $\frac{1}{8}$ held 2 inches away, the real degree of myopia is $\frac{1}{8+2} = \frac{1}{10}$. In hypermetropia we subtract the distance. If the fundus is seen best through a + $\frac{1}{8}$ held 2 inches away, the real degree of the hypermetropia is $\frac{1}{8-2} = \frac{1}{6}$.

Treatment.—The general directions are to avoid everything which tends to congest the eyes, such as reading in stooping or recumbent posture, by faulty light. The refraction is corrected by concave glasses, which render parallel rays divergent enough to be united on the retina. It is the rule to give the glass with which the best vision is obtained. Myopic eyes are frequently amblyopic also.

It is to be remembered in the treatment that myopia is essentially an elongated eyeball, made so usually by a giving way of the tissue, either in the ciliary region or about the optic nerve. It is therefore a pathological condition. A myopic eye is not often affected with asthenopia, but its use is often attended by pain, on account of the advance of the morbid condition which caused it, or in consequence of inflammatory conditions incidental to many myopic eyes. Asthenopia is much more frequent in hypermetropic and astigmatic eyes than in those that are myopic.

HYPERMETROPIA.

This usually depends upon too short an axis of the eye and exceptionally by the refractive power being too low. It may be congenital and hereditary. It is acquired by senile changes in the eye and by aphakia. The eye cannot see distant objects clearly without using a convex glass or (what amounts to the same thing) a certain degree of accommodation. The nearer the object, the greater the strain upon the accommodation. This leads to overtaxing

of the ciliary muscle and asthenopia, if the eyes are much used at fine work. It may also cause strabismus.

Manifest hypermetropia is that which is evident without paralyzing the accommodation.

Latent hypermetropia is that which is habitually concealed by the accommodation, but appears after the latter has been paralyzed by atropin. Latent hypermetropia tends to become manifest as age advances.

Facultative, or voluntary, hypermetropia is that variety in which the patient can see distant objects clearly with or without convex glasses, and can do fine work easily without glasses.

Absolute Hypermetropia.—That condition in which neither near nor distant objects can be seen clearly without convex glasses.

The strongest convex glass through which the patient obtains his maximum acuteness of vision for distant objects represents his manifest hypermetropia. A subject under 40 years of age will usually overcome 2 D of hypermetropia, if no astigmatism exist, without the need of a correcting glass. A degree of astigmatism equal to 1 D with the rule or even 0.25 D against the rule, as well as the higher degrees, will usually require correction to prevent asthenopia. In low degrees of hypermetropia with astigmatism in persons under 40 years of age it is usually sufficient to correct the corneal astigmatism alone. Lenticular astigmatism is of very rare occurrence, and need not be considered in the ordinary work of the ophthalmologist.

With the ophthalmoscope, the details of the fundus may be seen by the direct method some distance away, and if the head is moved to one side they are seen to move in the same

direction. On going closer, a certain convex glass will be needed behind a mirror to get a clear, erect image; and the focal length of the glass, *minus* its distance from the nodal point of the observed eye, equals the exact degree of the hypermetropia. The field of vision is larger and the image smaller than in emmetropia. By the indirect method the disc and vessels look larger than in emmetropia.

The *treatment* consists in correcting the refraction by suitable convex glasses. In manifest hypermetropia we may give for distance the strongest glass which gives the patient his most distinct vision.

ASTIGMATISM.

Astigmatism depends on the want of symmetry in the refracting surfaces; so that the refraction differs in the different meridians, and the retinal image is thus confused. Generally it is congenital, and may be hereditary. It is acquired by inflammation of the cornea, faulty union of the corneal incision after an operation, the use of improper glasses, or undue use of one eye to the exclusion of the other. The meridians of greatest and least curvature are called the *chief,* or *principal, meridians.* Corneal astigmatism is the form to be chiefly taken into account as a cause of asthenopia and amblyopia. That of the lens is usually unimportant.

The degree of corneal astigmatism can be accurately measured by an ophthalmometer (Javal, Paris, nineteenth century). This instrument consists essentially of a microscope which enlarges the corneal image of two figures by which the astigmatism is measured. It is more important exactly to estimate the degree of astigmatism than any other error of refraction. By the use of the ophthalmom-

eter the necessity for paralyzing the accommodation by atropin or homatropin is greatly limited,—nearly abolished, —for it is the astigmatism which is usually at the basis of the asthenopia, especially in hypermetropes, in whom astigmatism, as has been said, is much more apt to be an exciting cause of asthenopia than in myopia.

Astigmatism caused by different focal lengths of the principal meridians is called *regular.* That caused by the differences of refraction in the same meridian is called *irregular.* The latter form comes from irregularities in the structure of the lens or the cornea, either original *(normal irregular astigmatism)* or acquired through disease *(abnormal irregular astigmatism).* The chief subjective symptom is monocular polyopia (eye seeing more than one image) and metamorphosis; while the objective symptoms are irregular corneal reflections and changes of curvature, sometimes visible by oblique illumination, and distorted appearance of objects of the fundus, with parallax. Irregular astigmatism cannot be corrected although sometimes improved by glasses, but is occasionally ameliorated by stenopeic apparatus. Regular astigmatism is *simple* when one chief meridian is emmetropic and the other ametropic; *compound* when both are myopic or hypermetropic, but the defect is greater in one than in the other; *mixed* when one chief meridian is myopic and the other hypermetropic.

Astigmatism is corrected by means of cylindrical glasses. All corneæ are naturally astigmatic, the curvature being slightly stronger in the vertical than in the horizontal meridian. No inconvenience is usually felt unless As. = 0.75 D and not usually in less than 1 D. Very often low degrees of astigmatism do not become manifest, or at least disturb-

ing, until presbyopia occurs. It is therefore advisable to look carefully for this in presbyopes, especially in those who complain at all of asthenopia.

PRESBYOPIA: FAR SIGHT.

(Gr. πρεσβυς, an old man, and ὤψ, eye.)

This name is applied to the condition of diminished range of accommodation seen in elderly people—say, after 42 years of age. It consists in a recession of the near point, due to changes in the ciliary muscle and lens, so that the accommodative act can no longer render the latter as convex as before. The first symptom is that small objects cannot be seen clearly at so short a distance as formerly, but must be held farther away from the eye, especially in the evening. Distant vision, however, remains unimpaired unless the patient is hypermetropic to a considerable degree. Recession of the near point begins in all eyes in youth and gradually progresses during life. It does not usually cause inconvenience until after the age of 40. It appears earlier in hypermetropic eyes.

Presbyopia is assumed to begin when the near point has receded beyond 8 inches. The degree of presbyopia is found by deducting the patient's near point from this. Thus, if p. lies at 16 inches, Pr. $= \frac{1}{8} - \frac{1}{16} = \frac{1}{16}$. Presbyopia is easily corrected by convex glasses for reading, and they should be given as soon as the affection appears. It is usual to give the weakest glass with which No. 1 Jaeger type can be read at 8 inches from the cornea with difficulty. This glass usually enables a person to read and write comfortably at a convenient distance—that is, from 12 to 15 inches.

ANISOMETROPIA AND ANTIMETROPIA.

Differences in the refraction of the two eyes often occur, and are of great variety. The adjustment of glasses to such cases is largely a matter of experiment. As a rule, glasses which differ by more than two diopters are not well borne. This condition is called anisometropia or antimetropia (Gr. *ανισος*, unequal; *μέτρον*, measure; and *ὄψις*, vision).

APHAKIA: ABSENCE OF THE CRYSTALLINE LENS.

(Gr. ἀ, privative, and φακός, lens.)

This may be congenital or may result from absorption of the lens after injury, removal by operation, or dislocation. The refractive power of the eye is thus very much lessened. Accommodation, as a rule, is entirely absent. Exceptional cases have occurred where apparent accommodation remains in the lensless eye (Loring, Davis). Very strong convex glasses are required for close work, and somewhat weaker ones for distance.

PARALYSIS OF ACCOMMODATION.

This is sometimes seen in general debility of the system. It is frequent after diphtheria. It may be complete or partial. Is usually attended by dilation of the pupil. It causes marked inconvenience in emmetropic eyes, as the recession of the near point renders the patient unable to do any close work. Distant vision, however, is not impaired. In hypermetropes, both near and distant vision are disturbed. In myopes the impairment of vision is less, as they are still able to see clearly at their far point, which may be only a few

inches from the eye—*e.g.*, in myopia of three diopters. Convex glasses restore the vision for near objects at once. The diagnosis is easily made if the range of accommodation is tested.

The *treatment* consists primarily in removing any apparent cause—such as general debility. A myotic, locally, may be beneficial.

Spasm of the Ciliary Muscle (Apparent Myopia).

This sometimes occurs in ametropia, especially in hypermetropia, and also in emmetropia following upon undue straining of the accommodation. It causes asthenopia and dimness of vision for distant objects. The latter is perfectly relieved by weak concave glasses. The true state of refraction may be found by the ophthalmoscope, or, if there is doubt, atropin may be used.

Treatment.—A strong solution of atropin should be used until the spasm is completely overcome.

It is a rare condition, although formerly supposed to be very common.

The Shadow Test: Retinoscopy.

The refraction of an eye may be determined by observing the direction of the movement of a shadow seen by rotating an ophthalmoscopic mirror when illuminating the choroid and retina. If a concave mirror be used, the shadow will be seen to move in a direction opposite to the movement of the mirror in emmetropia, hypermetropia, and in myopia of so low a degree that the far point is at greater distance from the eye than that at which the mirror is held. A convex lens whose focus is the same as the distance that the mirror is held from

the eye being examined will stop or reverse the movement of the shadow in an emmetropic eye. In hypermetropia this glass must be subtracted from the glass that reverses the shadow. Example: If the shadow be reversed by a $+\frac{1}{15}$; that is, $\frac{1}{15}$ substracted from $\frac{1}{30}=\frac{1}{30}$ hypermetropia. In myopia this glass is *added* to the concave glass which reverses the shadow. Example: Examination at 30 inches: $\frac{1}{30}$ glass is required to reverse the movement of the shadow: $\frac{1}{30}+\frac{1}{30}=\frac{1}{15}=$ M. In the examination for astigmatism, the refraction of any one meridian can be ascertained by noting the movement of the shadow in that meridian. Both the test by the refraction ophthalmoscope and that by the shadow are often unreliable on account of the constant action of the muscle of accommodation. Full paralysis, attained by the local use of atropin, remains the only infallible means of enabling one to measure the refraction exactly by retinoscopy.

Fortunately, however, it is rarely necessary exactly to measure the degree of the error, if the astigmatism be carefully measured by the ophthalmometer. Except in cases of spasm, which are comparatively rare, the hypermetropia or myopia can be measured by the ophthalmoscope and test glasses.

Simulated Blindness.

This is not infrequently seen, and sometimes it is very difficult to detect. Simulated blindness of one eye may be detected by holding a prism before the healthy eye, when, if the patient sees two images, simulation is proved. If the eye is truly blind, the pupil should be partly dilated and insensible to light when the healthy eye is closed;

but when the latter is exposed to light both pupils should contract together. The stereoscope is also used, with slides having two different kinds of print or figures upon them, which are so arranged as to undergo a transposition when seen through the instrument. Thus, if the patient is simulating blindness of his right eye, he will naturally say that he sees only the left hand figure in the stereoscope; but this really belongs to the right eye, and so the fraud is exposed. Various trials with test-types and glasses (noticing whether the patient's statements are consistent) are useful. When atropin has been put into the eye for purposes of deception the pupil is noticed to be dilated *ad maximum,* and does not act with that of the other eye. In absolute blindness of both eyes, pupils should not contract under a bright light.

PHOTOPSIA (Gr. φως, light, and ὄψις, sight), or PHOSPHENES, are flashes of light, fiery sparks, luminous rings, etc., which patients describe as seen before their eyes. They occur in retinal inflammations, after blows upon the eye, etc. They also occur in blind eyes.

MICROPSIA (Gr. μικρος, small, and ὄψις, sight).—Objects appear smaller than they really are. It occurs in diseases which disturb the rods and cones of the retina. Also in affections of the third nerve.

MACROPSIA (Gr. μακρος, large, and ὄψις, sight), is due to disturbances of the third nerve.

METAMORPHOPSIA (Gr. μεταμορφοω, to transform).—Here the objects appear distorted. It occurs in retinal disease and in irregular astigmatism.

Color-blindness: Daltonism.[1]

This is an inability to distinguish colors, and is of variable degree. It is congenital, or the result of disease, especially of atrophy of the optic nerve. It may also be produced by long-continued strain of the eyes in working at colors. If only two of the three primary colors can be seen, the condition is called *dichromatic vision.* Where no color can be distinguished the condition is called *achromatic vision.* It is more frequent in males than in females. Red-blindness is the most frequent form. As has been already said, the late Professor Rood, of Columbia College, demonstrated the fact that color-blindness had been too sharply demarcated from a perfect color-sense. There are varying degrees, and eyes not at all color-blind of capacity to perceive colors accurately.

---

[1]After the chemist Dalton, who first described it.

PART II.

ANATOMY AND DISEASES OF THE EAR.

PART II.

ANATOMY AND DISEASES OF THE EAR.

CHAPTER V.

ANATOMY AND PHYSIOLOGY OF THE EAR.

General Considerations.

The auditory apparatus consists of a complicated structure *(the ear)* for collecting sonorous impressions, and conveying them to the auditory nerve, which transmits them to the brain. Delicate parts of the ear are securely imbedded in the petrous portion of the temporal bone. The sound-waves are collected by the auricle, conveyed through the external auditory canal, and received upon the membrana tympani, which is thrown into corresponding vibrations. These vibrations are conveyed by the chain of bones through the tympanum to the fluid of the labyrinth, and so to the terminal auditory nerves. The impressions there received are transmitted to the brain, where they are perceived as *sound.* The membrana tympani is so arranged as to undergo variations of tension in accordance with the different kinds of waves which strike it. The pressure of the air in the tympanic cavity is regulated by its communications with the mastoid cells, and with the pharynx through the Eustachian tube. The component parts of the terminal auditory ap-

paratus in the cochlea are supposed to be tuned to vibrate in sympathy with all the different notes which are appreciable in our musical scale. The semicircular canals have been considered as governing the equilibrium of the body and as having little or no part in the function of hearing. (Buck suggests that they may serve as safety valves to protect the terminal apparatus from injury in cases of very loud or sudden noise where the stapes is driven violently against the fenestra ovalis.) Our knowledge of the physiology of audition is still incomplete on several points.

THE ANATOMY OF THE EAR may be conveniently divided, for the sake of description, as follows:—

1. EXTERNAL EAR.......	(a) *Auricle.* (b) *External auditory canal.*
2. MIDDLE EAR.........	(a) *Membrana tympani.* (b) *Cavity of tympanum.* (c) *Mastoid cells.* (d) *Eustachian tube.*
3. INTERNAL EAR.......	(a) *Vestibule.* (b) *Semicircular canals.* (c) *Cochlea.* (d) *Auditory nerve.*

THE EXTERNAL EAR.

The *auricle* (Lat. *auris,* ear), or *pinna* (Lat. *pinna,* a mussel), is the external funnel-shaped appendage fastened to the malar and temporal bones by elastic fibers. It has a fibrocartilaginous framework closely covered by perichondrium and skin. The latter forms a projection from the lower

end of the cartilage called the *lobe* of the ear. The outer edge of the auricle is called *helix* (Gr. ἐλλισσω, to twist). Within the helix is the *fossa navicularis* (Lat. *navicula,* small boat). At the inner edge of this is another ridge, the *antihelix.* In front of the auditory canal is a projection called the *tragus* (Gr. τράγος, goat; because hairs like a goat's beard usually grow here). Opposite this on the other side of the canal is a similar projection, the *antitragus.* The concavity around the orifice of the canal is called the *concha* (Gr. κόγχη, concave shell). Above this is a triangular depression, the *fossa triangularis.* The skin of the auricle is covered by downy hairs, and contains sebaceous glands (largest in the concha) and sweat-glands (chiefly on the side next to the skull).

THE MUSCLES OF THE AURICLE.

The Levator or Attolens Aurem.—Origin, aponeurosis of the occipito-frontalis. Fan shaped. These fibers converge to their insertion at the upper part of the auricle. It lifts the auricle. It is supplied by the small occipital nerve.

The Attrahens Aurem.—Origin, the lateral edge of the aponeurosis of the occipito-frontalis. The insertion is in front of the helix. It draws the auricle forward and upward. It is supplied by the facial and the auriculo-temporal branch of the inferior maxillary nerve.

The Retrahens Aurem.—Origin is the mastoid process by short aponeurotic fibers. Insertion is lower part of the cranial surface of the concha. It draws the auricle backward. It is supplied by the posterior auricular nerve from the facial.

The following named muscles are rudimentary in man:—

Intrinsic Muscles: Muscles of Animal Life.—Slightly developed; sometimes absent:—

Tragicus.—It lies on the anterior surface of the posterior wall of the cartilage of the auditory canal.

Antitragicus.—Lies on the posterior surface of the posterior wall of the cartilage of the auditory canal.

Helicis Major.—Runs over the anterior margin of the helix and passes into the levator aurem.

Helicis Minor.—Lies on the lateral surface of the helix between its root and spine.

Transversus Auriculæ.—Runs on the posterior surface of the auricle from navicular fossa to the concha across the furrow corresponding to the antihelix.

Obliquus Auriculæ.—Runs on the posterior surface of the auricle over the furrow corresponding to the lower root of the antihelix.

Dilator of Concha.—On the tragus.

THE BLOOD-VESSELS OF THE AURICLE.

These are: *Posterior auricular artery* from the external carotid.

Anterior auricular artery from the temporal.

Auricular branch from the occipital.

The *veins* empty into the temporal, external, jugular, and posterior facial. There is a network of *lymphatics.*

THE NERVES OF THE AURICLE.

These are: *Auriculus magnus,* from the cervical plexus, on the posterior surface of the auricle.

Posterior auricular from the facial.

Auricular branch from the pneumogastric.

Auriculo-temporal branch from the inferior maxillary.

External Auditory Canal: Meatus Auditorius Externus (Latin equivalent).—It runs from the auricle to the membrana tympani, forward and inward, with crooked course, the principal curve having its convexity upward, so that the canal is higher in the middle than at either end. The average length is about 1 inch. The width varies; the widest parts are at the junction of the bone and cartilage and close to the membrana tympani. The outer third is cartilaginous, continuous with the cartilage of the auricle, and interrupted by fissures, *incisuræ Santorini,* filled with fibrous tissue. The inner two-thirds is bony—part of temporal bone. (The superior and posterior walls are developed from the temporal bone in general growth of the skull; the anterior and inferior walls are formed from tympanic ring, or *annulus tympanicus* [Latin equivalent], of fetus—an oval bony ring, with the upper one-fourth wanting, which is independent at first, but finally joins with the remainder of the bone. At birth no bony canal exists, it being represented by a membrane, which disappears as the bone grows outward.) At the bottom of the canal, in the annulus tympanicus, is the tympanic groove, *sulcus tympanicus* (Latin equivalent) for insertion of the membrana tympani. The groove and ring are interrupted above by a segment of irregular outline, about $^1/_{10}$ inch high and $^1/_8$ inch wide, the *segment of Rivinus* (Rivinus, Leipzig, eighteenth century). Each end of the segment is marked by a projecting bony spine. Helmholtz (Berlin, nineteenth century) calls the anterior point, *spina tympanica major* (spina tympanica posterior of Henle), and the posterior one,

spina tympanica minor. Owing to the oblique position of the membrana tympani, the anterior and inferior walls of the canal are longest. The canal is lined by integument containing soft hairs and sebaceous and ceruminous glands. The latter are like sweat-glands. *Cerumen* (Latin for wax) consists chiefly of fat and coloring matter. The integument becomes thinner as it approaches the membrana tympani. The canal is in relation in front with the articulation of the lower jaw; in front and below with the parotid gland; behind with the mastoid cells and transverse sinus; above with the mastoid cells, dura mater, and middle fossa of the skull.

The Vessels.—These are the posterior auricular artery; the deep auricular from the internal maxillary, entering at the articulation of the lower jaw. The largest vessels run on the upper and the posterior walls.

The nerve-supply is from the third branch of the fifth and from the pneumogastric, entering through the anterior wall.

The Middle Ear.

The Membrana Tympani, or Drumhead.—It lies at the inner extremity of the external auditory canal, separating it from the tympanic cavity. It is placed obliquely, forming an acute angle (45 degrees) with the inferior and the anterior walls of the canal and an obtuse one with the superior and the posterior walls. The upper border is about $^1/_4$ inch nearer to the entrance of the canal than the lower; the posterior border is about $^1/_5$ inch nearer than the anterior. (In the infant it lies more horizontally and nearly in a line with the upper wall of the canal.) It is of ellipsoidal shape,

with long axis (about $^1/_3$ inch) downward and forward. At the upper part it presents a conical protrusion, the apex corresponding to the short process of the malleus and the base spreading out in front and behind, forming *anterior* and *posterior folds,* the anterior being the shorter one. The general position of the membrane is arched, with the concavity outward. The deepest concavity surrounds the end of the handle of the malleus and is called the *umbo* (Latin for boss, of a shield). The drum-membrane is inelastic, about $^1/_{250}$ inch thick, about as thick as letter-paper, and is composed of three layers: a middle fibrous layer, covered externally by the skin of the auditory canal, and internally by the mucous membrane of the tympanum; the dermoid layer is very thin and devoid of hairs and glands; the middle layer, *lamina propria,* presents two layers of fine fibers—an outer *radiating* and an inner *circular.* In the anterior half of the membrane the outer fibers radiate from the tip of the malleus as a center; in the posterior half they radiate from the entire length of the handle of the malleus. In the center of the membrane the circular fibers form a very thin layer, which grows thicker toward the periphery and there becomes thin again or disappears. Between some of the fibers are cells—*corpuscles of von Tröltsch* (Anton von Tröltsch, Wurzburg, nineteenth century). The short process and handle of the malleus are imbedded between the radiating and circular fibers. On the tympanic side of the membrane is a fibrous fold from $^3/_{25}$ to $^4/_{25}$ inch high and $^4/_{25}$ inch broad, running from the posterior and superior border of the bony ring to the handle of the malleus, forming a pocket opening downward, called the *posterior pouch.* There is a similar space in front of the malleus, the *anterior pouch,*

formed by the spina tympanica major, the long process of the malleus, mucous membrane, anterior ligament of the malleus, chorda tympani nerve, and the inferior tympanic artery. At the margin of the drumhead its layers unite to form a tendinous ring, which is inserted into the sulcus tympanicus.

Tendinous bands run from the end of the Rivinian segment to the short space, including the Rivinian segment filled by the dermoid and mucous layers, which is more flaccid than the remainder of the membrane, which is called *membrana flaccida,* or *Shrapnell's membrane* (H. J. Shrapnell, London, eighteenth century). A minute opening is supposed by some to exist in this part and is called the *Rivinian foramen.*

The blood-vessels to the outer layer are from the deep auricular artery. Those to the inner are from vessels of the tympanum. The two layers communicate by a capillary network in the middle layer.

The nerves are in all the layers—in the outer from the superficial temporal of the fifth; in the inner from the tympanic plexus and the nerves of the skin.

The lymph-vessels are found in all the layers.

Seen through the auditory canal, the normal membrana tympani presents a delicate bluish-gray color and is quite translucent. The short process of the malleus appears as a whitish tubercle at the upper border, and the handle of the malleus as a whitish stripe running from this downward and backward toward the center of the membrane, and dividing it into anterior and posterior parts, of which the former is the larger.

The *"light spot"* is a bright, triangular reflection with its apex toward the tip of the malleus handle, and base from

$^1/_{25}$ to $^1/_{15}$ inch broad) toward the periphery of the membrane. It results from the oblique position of the membrane and from its marked concavity at this point. Sometimes one or two fine vessels may be seen, especially along the malleus handle.

THE CAVITY OF THE TYMPANUM, OR DRUM OF THE EAR.

(Lat. *tympanum*, drum.)

This cavity is an irregular, air-containing space lying behind the drumhead. It is lined by mucous membrane continuous with that of the Eustachian tube and pharynx. Average diameters: antero-posterior, $^1/_2$ inch; anterior vertical, $^1/_5$ to $^1/_3$ inch; posterior vertical, $^3/_5$ inch; anterior transverse, $^1/_8$ to $^1/_6$ inch; transverse opposite the drumhead, $^1/_{12}$ inch. Folds of mucous membrane stretch from one bony point to another, in some places forming prominent ridges.

The *anterior wall* presents, at its upper part, the opening of the Eustachian tube. The canal for the tensor tympani muscle lies above the Eustachian tube, separated from it by a thin plate of bone,—*septum tubæ,*—which ends by a small projection into the tympanum—*processus cochleariformis.* The *posterior wall* separates the tympanum from the mastoid cells and presents openings into the cells at the upper part, close under the roof. The *outer wall* is composed chiefly of the drumhead, but extends farther backward and upward than this. It has three openings: (1) the *iter chordæ posterius* (Lat. *iter,* a path), on a level with the center of the drumhead and close to its posterior edge, the opening of a minute canal which descends in front of the Fallopian canal

and finally joins it. The *chorda tympani* nerve enters here, runs up under the long process of the incus on the free edge of the posterior pouch, then forward across the neck of the malleus, and leaves the tympanum by (2) the *iter chordæ anterius,* or canal of Huguier, situated just in front of membrana tympani and running parallel with (3) the *Glaserian fissure,* opening above and in front of the membrana tympani, receiving long process of the malleus, ligamentum mallei anterius, and tympanic artery.

The *inner wall* forms the outer wall of the labyrinth. It presents the *fenestra ovalis* (Latin for oval window), an oval opening $^1/_{15}$ inch high, opposite the upper part of the drumhead and leading into the vestibule. It is closed by a membrane, on which rests the base of the stapes. A smaller opening below the latter—*fenestra rotunda* (Latin for round window), $^1/_{12}$ inch in diameter, leads into the cochlea. It is closed by a membrane called the *membrana tympani secundaria.* In front of the fenestræ and extending between them is a rounded projection, the *promontory,* corresponding to the first whorl of the cochlea. On its surface are grooves for nerve-twigs. In front of the promontory the wall is very thin and covers the carotid artery. Above and behind the fenestra ovalis is a ridge corresponding to the Fallopian canal, which contains the facial nerve. Behind and below the fenestra ovalis is the *pyramid,* or *eminentia stapedii,* a conical eminence containing a circular canal which incloses the stapedius muscle and communicates below with the Fallopian canal. On a level with the *fenestra ovalis* and behind the ridge of the Fallopian canal is a smooth surface corresponding to the horizontal semicircular canal. The *upper wall* is very thin *(sometimes wanting),*

and separates the tympanum from the cranial cavity. The *lower wall*—sometimes, but rarely, is very thin or wanting—separates the tympanum from the jugular vein. It is pierced by the glosso-pharyngeal nerve.

OSSICULA AUDITUS.

The ossicles of the ear, or ossicula auditus (Latin equivalent), are three small bones—*malleus* (Latin for hammer), *incus* (anvil), and *stapes* (stirrup)—which form a chain across the tympanum. They are covered by very thin periosteum and mucous membrane. The *malleus* presents a head; a neck; a short process; a handle, or *manubrium* (Latin for handle); and a long process, processus gracilis or folianus. The handle and short process are attached to the middle layer of the drumhead. The attachment is firm at the end of the handle, looser about the short process, leaving a kind of joint space there. The long process runs forward and outward toward the Glaserian fissure; $3\,{}^1/_2$ lines long in infants. It is reduced to a short stump in adults. The head and neck of the malleus are attached by ligamentous fibers. Those running from the spina tympanica major to the neck of the hammer and enveloping the long process up to the Glaserian fissure, called *ligamentum mallei anterius;* those radiating from the neck of the malleus to the border of the Rivinian segment, *ligamentum mallei externum;* those running from the head of the malleus to the roof of the tympanum, *ligamentum mallei superius.* The most posterior group of the ligamentum externum is called *ligamentum posticum,* and this, with the middle group of the ligamentum anterius, is called the *axis band* of the hammer (Helmholtz). The head of the malleus articulates with the

incus by a peculiar joint containing a *cog*, which allows the malleus to rotate outward, but prevents it from rotating inward without carrying the incus with it.

The *incus* presents a head and a long and a short process. The head articulates with the malleus. The incus is joined to the tympanic roof by the *ligamentum incudis superius*. The short process runs back and articulates with the posterior wall of the tympanum. The long process descends parallel with and behind the handle of the malleus, and ends in a lens-shaped tip which articulates with the head of the stapes. This joint is a flat segment of a sphere, convex toward the stirrup.

The *stapes* presents a head, a neck, crura, and a base. The head articulates with the incus. The base is surrounded by a lip of fibrocartilage and rests in the fenestra ovalis; union between it and the wall of the vestibule is by the periosteum of the latter extended over the base. A thin membrane inserted into the side of the base and the inner edges of the crura, closing the opening between them, is called the *ligamentum obturatorium stapedium*.

The joints of the ossicles are provided with articular cartilages and capsules. The *tensor tympani muscle* arises from the periosteum of the upper wall of the cartilage of the Eustachian tube, and from the neighboring border of the sphenoid. Before leaving the canal it becomes tendinous, and the tendon turns around the processus cochleariformis at nearly a right angle, to be inserted into the anterior half of the inner side of the hammer at the beginning of the handle and a little below the short process. It is supplied by a nerve from the otic ganglion. It draws the handle of the hammer inward and renders the membrana tympani tense, and all

the ligaments of the ossicles (except the superius mallei) are simultaneously put on the stretch; at the same time the long process of the incus is made to rotate inward with the malleus handle, and so to press the stirrup against the oval window and the fluid of the labyrinth. The *stapedius muscle* arises from the cavity in the pyramid in which it lies. The tendon leaves the canal at an obtuse angle and is inserted into the neck of the stapes. It is supplied by a nerve from the facial. It is supposed to depress the base of the stapes and so compress the contents of the labyrinth.

The dimensions of the ossicles are: Length of *malleus* from the summit of the head to the short process, about 4 $^1/_2$ millimeters; from the short process to the end of the handle, 4 to 5 millimeters; long process, about 2 millimeters. Length of *incus* from the summit of the head to the end of the long process, about 6 $^1/_2$ to 7 millimeters; to the end of the short process, about 5 millimeters. Length of *stapes*, about 3 millimeters; greatest distance between crura, about 2 millimeters; length of the base, about 3 millimeters; width, about 1 millimeter.

The long process, or processus Folianus (Cœlius Folius, Venice, 1645), of the malleus is also called the process of Rau, after Prof. Jacob Rau, of the University of Leyden.

The Arteries of the Tympanic Cavity.—There are: the tympanic branch from the internal maxillary, entering by the Glaserian fissure; the stylo-mastoid branch from the posterior auricular, entering by the stylo-mastoid foramen; the petrosal branch from the middle meningeal, entering by the hiatus Fallopii; and branches from the ascending pharyngeal and internal carotid, entering by the median wall of the Eustachian tube.

The *veins* empty into the middle meningeal and pharyngeal veins.

The Nerves.—For a description of the nerves supplying the muscles see description of the latter. Those to the mucous membrane are from the *tympanic plexus,* which is formed from the tympanic branch (Jacobson's nerve) of the petrous ganglion of the glosso-pharyngeal, entering by a small foramen below the promontory; from a branch of the superficial petrosal, entering from above; and from branches from the carotid plexus of the sympathetic, entering through the wall of the carotid canal. The *otic ganglion* is situated near the foramen ovale of the great wing of the sphenoid in front of the middle meningeal artery, on the outer side of the cartilage of the Eustachian tube and the origin of the tensor palati muscle, and internal to the inferior maxillary nerve. It receives fibers from the third division of the fifth, from the auriculo-temporal, and from the sympathetic plexus around the middle meningeal artery. It communicates with the glosso-pharyngeal and facial nerves through the small petrosal. It sends branches to the *tensor tympani* and the *tensor palati* muscles. The *chorda tympani nerve* passes across the tympanum (between the handle of the malleus and the long process of the incus and along the lower margin of the posterior pouch of the membrana tympani), but it seems to have no physiological relation to it.

The mastoid cells consist of a large number of irregular cells, of varying size, contained in the mastoid process of the temporal bone. As a whole, they are surrounded by a dense cortical layer of bone $^1/_{25}$ to $^1/_{12}$ inch thick. In the upper part of the process there is a single large cell, the *mastoid an-*

trum (Lat. *antrum,* cave), which communicates with the lower cells, and from which one or more openings lead into the tympanum through its anterior wall. The cells are lined by thin mucous membrane. At birth the mastoid process is rudimentary and contains only one large cell, which corresponds to the antrum.

The *vessels* of the mastoid cells are from the stylo-mastoid branch of the posterior auricular.

The *nerves* are from the tympanic plexus.

The Eustachian tube (Eustachius, Venice, sixteenth century) leads from the pharynx upward, outward, and backward to the tympanum at an angle of 135 degrees with the axis of the external auditory canal. It consists of cartilaginous and bony portions, the whole length being about 1 $^2/_5$ inches. The tympanic end is bony, triangular in shape, and about $^1/_2$ inch long and $^1/_{12}$ inch in diameter. The outer wall belongs to the *pars tympanica,* the median wall separates the tube from the carotid canal, and the upper wall, *septum tubæ,* from the canal of the tensor tympani muscle. The point of union with the cartilage is jagged, and the median wall runs farther back than the outer. The cartilage of the tube consists of two plates, a *median* triangular one, which is the larger, and into whose upper and outer part is inserted the smaller, hook-shaped *outer* one, which is attached to the base of the skull. The remaining wall of this part of the tube (equal to about half its circumference) is formed of membrane. The narrowest part of the tube is at the isthmus, the junction of the cartilaginous and bony parts. The pharyngeal orifice is trumpet-shaped, about $^1/_3$ by $^1/_5$ inch in diameter, and lies in the posterior nasal space a little above the floor of the nostril. The inner wall projects

slightly on to the pharynx, so that the mouth of the tube lies rather in a frontal plane. The tube is lined with mucous membrane, which in the bony part adheres very closely to the periosteum. It contains numerous acinous glands, which decrease toward the tympanic end. The membrane is quite thick at the pharyngeal end. The epithelium, with which it is lined, is ciliated, with motion of the cilia toward the pharynx.

The Muscles of the Eustachian Tube.—Abductor or *dilator of the tube (spheno-salpingo-staphylinus, circumflexus palati,* or *tensor palati mollis).*—The origin is from the sphenoid bone and the cartilage of the tube. The insertion is to the convex border of the outer cartilage along its whole length. Fibers pass forward, inward, and downward, and spread over the edge of the soft palate and side of the pharynx. It draws the hook of the outer cartilage forward and downward, enlarging the caliber of the tube. Fibers are said to pass into those of the tensor tympani. It is supplied by the internal pterygoid nerve.

The Levator Veli Palati.—The origin is from the lower surface of the temporal bone on the anterior border of the entrance to the carotid canal, and from the cartilage of the tube. The insertion is in the region of the osseous tube on the bone, cartilage, and mucous membrane of the tube. It presses the membranous floor of the tube forward, enlarging the transverse diameter. It is supplied by the pneumogastric nerve.

The salpingo-pharyngeus is a thin muscular layer connected to the lower end of the median cartilage to the mucous membrane and the posterior wall of the pharynx. It is considered as a fixator of the median cartilaginous plate. It is called fascia by some.

The Vessels of the Tube.—The ascending pharyngeal is from the external carotid; the middle meningeal is from the internal maxillary; and there is a branch from the inferior carotid.

The Nerves of the Tube.—Superior pharyngeal from the fifth—glosso-pharyngeal.

Whether the tubes are normally open or closed is disputed. They are opened during the act of swallowing. A semicylindrical space under the hook of the cartilage is called the *safety tube,* and is supposed to be always open.

The Internal Ear, or Labyrinth.

This is the essential part of the hearing apparatus, containing the ultimate filaments of the auditory nerves. It comprises several osseous cavities contained in the petrous bone, within which are corresponding membranous sacs, receiving the distribution of the nerve. These sacs and intervening spaces are filled with a clear fluid.

The bony cavities are:—

1. *Vestibule.*
2. *Semicircular canals.*
3. *Cochlea.*

The *vestibule* is irregular and ovoid in shape; the diameters from above downward and from behind forward are about $^1/_5$ inch, and from without inward about $^1/_{10}$ inch. The *outer, or tympanic, wall* contains the *foramen ovalis;* above this is the anterior opening of the horizontal semicircular canal. On the *inner wall,* near the upper anterior edge, are two depressions, the *recessus ellipticus* and the *recessus sphericus,* and a small ridge separating them called the *crista vestibuli.* The crista runs above into a pyramidal

elevation, the *pyramis vestibuli;* below, it divides into two branches, which inclose a space called the *recessus cochlearis.* The recessus ellipticus is partly bounded below by a shallow furrow, the *sinus sulciformis;* just above the recessus the ampullar orifice of the anterior vertical semicircular canal opens; at the posterior part of the inner wall is the opening of the *aquæductus vestibuli*—a fine canal running into the vestibule from the posterior surface of the petrous bone. It contains the tubular prolongation of the lining membrane of the vestibule, ending in the cranium between the layers of the dura mater. At the junction of the inner and the posterior walls is an opening common to both vertical semicircular canals. At the same level in the middle of the posterior wall is the posterior opening of the horizontal semicircular canal. In the angle of the posterior lower and inner walls is the lower opening of the posterior vertical semicircular canal. Anteriorly, on the apex of the vestibule below the recessus sphericus and below the anterior edge of the fenestra ovalis, the scala vestibuli of the cochlea begins. The *maculæ cribrosæ* (Lat. *macula,* spot, and *cribrum,* a sieve), for entrance of twigs of the auditory nerve, are on the inner wall, but are only visible in the adult and by the microscope. Each macula consists of a group of fine holes. The largest one, *macula cribrosa superior,* lies at the upper end of the crista vestibuli, and admits nerves to the utricle and to the ampullæ of the anterior vertical and horizontal semicircular canals. The *macula media* lies in the recessus sphericus, and admits nerves to the saccule. The *macula inferior* lies at the ampullar opening of the posterior vertical semicircular canal, and admits nerves to the ampulla. A fourth macula lies in the upper part of the recessus cochlearis, and admits a twig

of the cochlear nerve to the septum between the utricle and the saccule.

The semicircular canals are C-shaped, starting from the vestibule and returning to it again. The horizontal one is convex laterally. The other two are vertical (anterior and posterior) and at right angles to each other. There are five openings in all, one being common to both vertical canals. These openings are called *ampullæ,* from their flask-shape (Lat. *ampulla,* flask). Their dimensions vary. The length of the anterior vertical is $^4/_5$ inch; of the posterior vertical, about $^{11}/_{12}$ inch; of the horizontal, about $^1/_5$ inch. The part common to both vertical canals, the *canalis communis,* is about $^1/_{12}$ to $^1/_8$ inch long. The average diameter of the canals is from $^1/_{20}$ to $^1/_{15}$ inch. The openings of the anterior vertical canal are close together and at about the same height; those of the posterior vertical stand one above the other; those of the horizontal close to those of the anterior vertical.

The Cochlea.—This is so called from its resemblance to a snail (Lat. *cochlea,* snail), and is a tube which coils around a central pillar, or axis, and tapers toward one extremity, where it ends in a *cul-de-sac.* It is about $1\,^1/_2$ inches long and $^1/_{10}$ inch in diameter at the beginning and $^1/_{20}$ inch at the end. It makes two and one-half turns from below upward, from left to right in the right ear, and *vice versa* in the left ear. The apex, or *cupola,* is directed forward and outward, with a vaulted roof. The cochlea is separated in front by a thin wall from the carotid canal. Inward, it strikes upon the blind end of the internal auditory canal and encroaches as the *promontory* on the inner wall of the tympanum. The *axis, spindle,* or *modiolus* (Lat.

modiolus, hub of a wheel), is composed of the inner walls of the tube and of a central spongy bone substance circumscribed by its turns. It diminishes in diameter from the base to the apex, being about $^1/_8$ inch in diameter at the former and $^1/_{50}$ inch at the latter. Its length is about $^1/_6$ inch. The base rests upon the bottom of the internal auditory meatus. The apex forms the inner wall of the last half-whorl, ending in a thin lamellalike section of a funnel, called *infundibulum* (Latin for funnel).

The central spongy substance is penetrated by numberless small canals which run outward from the base to the spiral lamina, and allow passage of the nerves and vessels from the *meatus auditorius internus.* Two of the canals running in the spongy substance have names. Their walls are perforated by fine holes corresponding to canals running to the spiral lamina. One, *canalis centralis modioli,* begins in the fossa cochlearis and runs in the axis of the modiolus from the base to the apex. The other, the *canalis spiralis modioli,* or *canalis ganglionaris,* runs spirally along the outer wall of the modiolus at the line of junction of the lamina spiralis; it is oval in form, and separated from the scala tympani by a thin, cribriform lamella, and ends at the apex near the hamulus. These canals transmit vessels and nerves.

In the *canalis spiralis* lie ganglia of the cochlear nerve. On the outer surface of the modiolus, and running spirally around its axis from the base to the apex, is a projecting bony ledge called the *lamina spiralis ossea.* It is made up of two lamellæ, which at its base, where they come off from the wall of modiolus, inclose spongy bone substance communicating with the *canalis spiralis modioli.* Its free edge, where

the lamellæ approach each other, is thinner. The posterior lamella forms the outer wall of the *canalis spiralis,* while the anterior passes into the wall of the *scala vestibuli.* The lamina diminishes in width and thickness toward the apex. In the first whorl it projects into the tube of the cochlea $^1/_{20}$ inch; in the last whorl $^1/_{50}$ inch. At the apex it ends in a bony hook, the *hamulus* (Latin for small hook), projecting into the cupola. The *ductus cochlearis,* or *lamina spiralis membranacea,* stretches from the free edge of the bony lamina across to the outer wall of the cochlear canal. A complete partition is thus formed dividing the canal into two passages, or *scalæ* (Latin for stairways). The lower scala has its base turned toward the tympanum, coming upon the *membrana tympani secundaria,* and is called the *scala tympani.* The upper one alone opens into the vestibule (by the *recessus sphericus*) and is called the *scala vestibuli.* At the apex of the cochlea the two scalæ open into each other and connect with the arachnoidal cavity of the brain, the communication being called the *helicotrema* (Gr. ἐλισσω, to twist, and τρε̂μα, hole). (This communication is doubted by Buck.)

Two small canals open by one into the labyrinth and by the other on the surface of the petrous bone: 1. The *aquæductus vestibuli* is about $^1/_5$ inch long. It begins by a groove just below and in front of the opening of the two vertical semicircular canals, runs around the inner wall of the common canal, then down and back, and opens under a bony projection a little behind the middle of the posterior inner surface of the petrous bone. It transmits a small vein carrying blood from the semicircular canals and empties into a vein of the dura mater or into the inferior petrosal sinus. 2.

The *aquæductus cochleæ* is somewhat larger; it begins by a small orifice in the lower wall of the *scala tympani,* just above the *fenestra rotunda;* runs downward, inward, and forward in the inner wall of the jugular fossa; and opens at the bottom of the triangular depression toward the middle of the edge, which limits the inner and the inferior surface of the petrous bone. It transmits a vein carrying blood from the cochlea and empties into the jugular vein.

The *periosteum* of the labyrinth is, excepting that of the outer wall of the cochlear canal, very delicate. It consists of several layers of very fine fibrous network, compared by Henle to the *membrana suprachoroidea.* In the spaces of network are smooth round or elliptical nuclei, sometimes like epithelium. Stellate pigment cells and minute round or ovoid calcareous deposits are also present. There is a rich supply of vessels. From the periosteum of the vestibule and semicircular canals fine fibers and many blood-vessels run to the outer surface of the corresponding parts of the membranous labyrinth.

THE MEMBRANOUS LABYRINTH.

The *utricle* (Lat. *utriculus,* a little leathern bottle) is a flattened, elliptical tube placed upon the inner wall of the vestibule. The long diameter, $^1/_8$ inch, corresponds to the height of the vestibule, the upper end lying on the pyramid, the lower end lying opposite the ampullar opening of the posterior vertical semicircular canal. It is fastened to the recessus ellipticus by a fine vascular, nervous, and connective-tissue network. The outer wall is free and separated from the outer wall of the vestibule by a space filled with endolymph.

The Membranous Semicircular Canals.—These are of the same shape as the osseous, and open into the utricle by five openings, as do the osseous into the vestibule. At the ampullæ the membranous canals fill the osseous, but in the other parts there is considerable space between the two, which is filled by connective tissue, vessels, and fluid. The walls of the canals of the utricle are clear, transparent, and very delicate; about $^1/_{1250}$ inch thick, and composed of (1) an outermost layer *(membrana propria)* of reticulate and nuclear fibrous tissue pierced by blood-vessels; (2) a basal membrane; and (3) an innermost layer of pavement epithelium. On the inner surface of the walls of the canals, except on the side next to the bone, the membrane is thrown into numerous elevations. On the wall of both the utricle and the saccule is a more dense point, of circular shape, $^1/_{12}$ inch in diameter, the *macula acustica,* where the twig of the auditory nerve reaches it. There is a still more rigid spot, the *crista acustica,* embracing about one-third the circumference of ampulla, near its utricular orifice, of yellowish color, about $^1/_{50}$ to $^1/_{70}$ inch in diameter, sometimes surrounded by a pigment line, and receiving nerve-twigs also. The maculæ and cristæ present thickening of the *membrana propria,* from mingling of the connective tissue and a network of nerve-fibers, which enter the epithelial cells.

The *otolith* of the utricle (otoconia, ear sand, or ear crystal [Gr. ὀυς, ear, and λιθος, stone]) is a smooth, irregularly demarcated and uneven mass of white powder, loosely held together by mucoid substance. This powder consists of crystals of carbonate of lime, of varying form and size, the largest being about $^1/_{2000}$ inch long, and $^1/_{3000}$ inch broad. How the otolith is held to the wall of the utricle is not yet settled.

The *saccule* is a flask-shaped sac, whose body (about $^1/_{15}$ inch in diameter) lies in the *recessus sphericus,* its blind base being directed upward and forward against the utricle, the walls of the two sacs being united at a single point. The neck of the sac, the *canalis reuniens* (about $^1/_{85}$ inch long and $^1/_{120}$ inch diameter), runs from the lower wall down and back, and sinks into the upper wall of the vestibular end of the *ductus cochlearis* at nearly a right angle, so that a blind sac is formed at the junction of the two parts.

The *ductus cochlearis* begins with the above blind sac in the vestibule, and passes through the whole cochlea to the apex, where it ends in another blind sac. The lower end rests in the *recessus cochlearis,* the upper end in the cupola. The ductus is attached on one side to the *lamina spiralis ossea;* on the other to the outer wall of the bony cochlear canal. On cross-section it is triangular, the two walls diverging from the edges of the *lamina spiralis,* and the third, corresponding to the part of the cochlear wall, is comprised between the insertions of the other two. The lower wall, turned toward the scala tympani, is called *tympanal;* the upper, toward the scala vestibuli, is called *vestibular.* On the border of the *lamina spiralis ossea* is a soft structure —*limbus lamina spiralis*—which lengthens the lamina toward the ductus, and is developed from the periosteum of the former. The vestibular wall of the ductus passes off from the upper surface of the *lamina ossea* at the inner attachment of the limbus, so that the latter is included in the ductus.

The limbus has two lips—an upper, *labium vestibulare,* and a lower, *labium tympanicum.* The furrow between them is called the *sulcus spiralis internus.* The upper lip projects

like a roof over the sulcus, and its edge is divided by furrows into oblong sections, which on front view resemble the anterior surface of the incisor teeth, and are called *auditory teeth.* These furrows are filled with rounded (epithelial) cells, continuous with the layer covering the *membrana vestibularis.* The tympanic lip forms the floor of the sulcus, and has two layers, which unite in a sharp border, continuous with the membrana basilaris. The *membrana vestibularis,* or *Reissner's membrane,* forming the vestibular wall of the ductus, runs from the edge of the *lamina spiralis ossea* to the outer wall of the cochlea. It consists of a vascular, connective-tissue basis, covered by endothelium on the vestibular side and by epithelium on the tympanic side.

The *membrana basilaris* (Gr. *βασις*, base), forming the tympanic wall of the ductus, is a continuation of the *labium tympanicum,* and increases in width from the base to the apex of the cochlea as the lamina spiralis decreases. It is divided into two zones—an inner, *habenula tecta* (Lat. *habenula,* a little thong, and *tego,* to cover), and an outer, *zona pectinata* (Lat. *pectinatus,* comblike). The essential layer is a structureless membrane. This is thickest at the outer zone, and is there covered, on the tympanal surface, with knobby elevations. Imbedded in this basis substance is a small vein, *vas spirale,* anastomosing through radial branches with vessels of the lamina spiralis ossea. On the vestibular surface is a layer of very fine radiating fibers, which are most prominent in the zona pectinata. Sometimes fine spiral fibers are found on the tympanal surface. Corti's organ lies on the inner zone. The outer wall of the ductus presents internally the *membrana propria* of the ductus; externally, the periosteum, and, between, a semilunar cushion of con-

nective tissue. The points of insertion of the membrana vestibularis and the membrana basilaris are prominent. The former is called *angular vestibularis;* the latter, *ligamentum spirale.* A part of the membrana propria just above the ligamentum spirale is very vascular and is called *stria vascularis.* At the lower limit of the stria is an elevation, *ligamentum spirale accessorium,* containing a vessel, *vas prominens.* The space between this and the insertion of the membrana basilaris is called the *sulcus spiralis externus.*

The cavity of the ductus cochlearis is divided into two parts by a membrane, *Corti's membrane,* or *membrana tectoria* (Lat. *tectorius,* covering), which runs parallel to the membrana basilaris from the *labium vestibulare* to the outer wall of the cochlea. The latter insertion is about midway between membrana basilaris and stria vascularis. The upper space is filled with endolymph, while the lower contains the terminal auditory apparatus. The tectorian membrane is very delicate, but firm. It is divided into three zones. The inner one is structureless, pierced by numerous openings, and covers the labium vestibulare. The middle one is densest, and consists of several fine layers of parallel fibers. The outer one consists of a very fine and friable network. Henle thinks this membrane is firmly fastened, so that it cannot press closely upon the parts beneath. According to Waldeyer, however, the membrane ends near the outer wall by a thin, free margin, and rests directly on Corti's organ.

The *terminal auditory apparatus* (Henle) comprises the structures in the lower chamber of the ductus cochlearis.

The *auditory rods, pillars,* or *teeth of Corti* (Corti, Italy, nineteenth century) are arranged in regular order, somewhat like the keys of a piano. They are shaped like the

Roman S, with slender cylindrical bodies and broad ends, containing granular protoplasm. There are two rows—an *inner* (that nearest lamina spiralis) and an *outer*. The rods of each row rest by one end, or *pedestal,* on the membrana basilaris. They thence rise quite abruptly and unite with each other by their other ends, or *heads,* forming an arched roof over the inner zone of the membrana basilaris, the base of the arch being about $^1/_{250}$ inch broad. The inner rods are about $^1/_{35\,000}$ inch broad, while the outer rods are about $^1/_{25\,000}$ inch in diameter, longer than the inner and placed farther apart, averaging 7 or 8 to 12 of the latter. Pedestals of the inner row lie just outside the perforations in the *membrana basilaris* and the fine ends of the nerve-bundles. The tissue composing the rods is hard as cartilage (Henle). To the heads of the rods are fastened platelike processes—the *head-plates.* The inner rods have two,—one on the inner and one on the outer surface,—inclosing a smooth concavity between them, in which the heads of the outer rods rest, one of the latter articulating with two or more of the former. The plate on the head of each outer rod projects from the outer surface, like a phalanx, beyond the joint. The estimated number of pillars is: inner, 6000; outer, 4500. A perforated membrane, the *lamina reticularis* (Lat. *rete,* a net), arises from the articulation of the rods, and stretches, parallel to the membrana basilaris, to the outer wall of the cochlea. It is formed of a network of fine hyaline threads, with oblong and round meshes arranged in rows. The tissue, though delicate, is quite firm.

The *cells* found in the ductus cochlearis—*auditory cells*—are nucleated, round, and cylindrical. A layer of them covers the sulcus spiralis, Reissner's membrane, and

the outer wall of the ductus. Upon the inner pillars lies a single row of conical cells with large nuclei. They send processes into a row of small cells lying next them toward the sulcus—the *granular layer.* The ends turned toward the heads of the rods bear tufts of still, immovable cilia. These cells are called *inner hair-cells* (*inner roof-cells* of Henle) and their number is computed at 3300. On the outer rods lie three or four rows of double nucleated cells connected by slender processes to the *membrana basilaris* and the *membrana reticularis,* and bearing also tufts of cilia. They are called *outer hair-cells* (*outer roof-cells* of Henle), and their number is computed at 18,000. The cilia of the cells are received by the corresponding rows of openings in the *lamina reticularis.* Henle describes another layer of cells lying on the *membrana basilaris* beneath the rods as *floor-cells.* He considers the cells as epithelial or ganglionic. Waldeyer regards the cells, and also the rods of Corti, as epithelial structures.

The *auditory nerve,* or *portio mollis* (Latin for soft part), of the seventh nerve arises by two roots in the medulla oblongata. One ganglionic nucleus of origin is in the floor of the fourth ventricle. The other is in the *crus cerebelli ad medullam* (Stieda). The roots are connected with the gray substance of the cerebellum, with the flocculus, and the gray matter at the border of the *calamus scriptorius* (Gray). The nerve winds around the restiform body, from which it takes fibers; thence it runs forward across the posterior border of the crus, in company with the *portio dura,* or facial nerve. The two nerves then pass into the *meatus auditorius internus,* where some minute filaments connect them together. At the bottom of the meatus the facial nerve

enters the Fallopian canal; the auditory divides into two branches, *vestibular* and *cochlear,* the former of which here presents a ganglionic swelling—*intumescentia ganglioniformis Scarpæ.* The cochlear nerve gives off a small branch which, at the *recessus cochlearis,* passes to the vestibular end of the ductus cochlearis, and through the fourth *macula cribrosa* to the partition wall of the utricle and saccule. From the trunk of the nerve a number of fine branches then arise, which pass directly through the *tractus foraminosus* to the *lamina spiralis* of the lower wall of the cochlea. The remainder of the nerve enters the modiolus, in which it breaks up into fine anastomotic divisions. Bipolar ganglion cells are connected with the fibers. Bundles traverse the *ganglion spiralis* in the canalis ganglionaris at the beginning of the lamina spiralis, and finally pass into the latter. Fibers radiate with numerous anastomoses between the two plates of the lamina spiralis throughout all its turns. The *vestibular branch,* after its gangliose expansion, divides into three branches: 1. The *superior,* which passes through the *macula cribrosa superior* and ends by three branches to the utricle and ampulla of the superior vertical and horizontal semicircular canals. 2. The *middle* passes through the *macula cribrosa media* to the saccule. 3. The *inferior* passes through a bony canal of its own to the ampulla of the inferior vertical semicircular canal.

The *terminal nerve-fibers* pass from the lamina spiralis through fine holes in the labium tympanicum and in the membrana vestibularis into the ductus cochlearis. They run a radiate course, passing through the granular layer, whence some end in the inner hair-cells, and others run between the rods of Corti, and across the tunnel formed by them, to end

in the outer hair-cells. Other nerve- (?) fibers run a spiral course in the granular layer and the inner and outer hair-cells, but their exact origin and ending are unsettled.

The *blood-supply of the labyrinth* comes through the *auditiva interna* artery—a branch from the basilar of the vertebral. In the meatus internus the artery divides into *vestibular* and *cochlear* branches. The former passes in fine twigs through the posterior wall of the vestibule to the soft structures of the latter and of the semicircular canals. The latter sends fine branches through the tractus foraminosus into the modiolus, and thence between the layers of the lamina spiralis. Some small branches are said to go to the labyrinth from the stylo-mastoid.

THE INTERNAL AUDITORY CANAL, or *meatus auditorius internus,* begins at about the center of the petrous portion of the temporal bone by a large orifice with smooth, rounded edges, and runs directly outward about $^1/_3$ inch to end in a blind fossa. The floor of the fossa is marked by four depressions, which are perforated by fine foramina, through which the fibers of the auditory nerve enter the labyrinth. Three of them correspond to the *maculæ cribrosæ.* The fourth lies opposite the base of the cochlea, is spiral shaped with spirally arranged foramina, and is called the *tractus spiralis foraminosus.*

CHAPTER VI.

EXAMINATION AND DIAGNOSIS OF AURAL DISEASE.

TESTS OF HEARING.—A watch is held opposite the ear, and the farthest distance which its tick is heard is noted. It is usual to make this distance the numerator of a fraction whose denominator is the distance at which the tick is heard by a normal ear. The letters H.D. are used for designating *hearing distance,* R.E. for *right ear,* and L.E. for *left ear.* For example, if a normal ear hears the watch at 40 inches, and the right ear of the patient hears it at only 10 inches, we write H.D.R.E. $= \frac{10}{40}$. If the watch is heard only when it touches the auricle, H.D. $= \frac{\text{contact}}{40}$ or $\frac{c}{40}$. If when pressed against the ear, H.D. $= \frac{\text{pressed}}{40}$ or $\frac{p}{40}$. If not heard at all, H.D. $= \frac{0}{40}$. Sometimes the watch is only heard when pressed against the mastoid process. H.D. $= \frac{\text{mastoid}}{40}$ (Prout). The clicking noise made by snapping the edges of the finger-nails together is sometimes a convenient substitute for the watch-tick.

Another test—and the best—of hearing power is the *voice.* Stand behind the patient, and find at what distance he can hear ordinary or loud conversation. There is often a curious disproportion between the two tests; a patient who scarcely hears a watch at all may hear conversation at 10 feet. The voice test, therefore, gives the best idea of the *practical* hearing power possessed by the patient.

The *tuning-fork* is used to determine whether a lesion of the auditory nerve exists, but, as a matter of fact, it is

of little value in the aid of diagnosis. The heavy fork of low pitch with movable clamps attached to each arm is very useful as well as the fork C^2. While vibrating, it is held in front of the auditory meatus, and then, having been newly set in vibration, the handle is held on the mastoid process. If heard better and longer through the air than through the bones, if the aërial conduction is better than bone conduction, disease of the nerve, either primary or secondary, is supposed to exist. If it be heard better and longer through the bone, disease of the middle or external ear, or of both, is present. The above is Rinné's test. When the fork is heard longer through the air it is called "positive," or plus; when heard longer through the bone, "negative," or minus. In old persons the aërial is usually better than the bone conduction and the hearing is somewhat less acute, probably from disease of the nerve, or perhaps from failure of the muscular power also (presbykousis—Roosa).

Politzer's acoumeter is a *cheap, convenient,* and *uniform* test for the hearing. It consists of essentially a steel cylinder 28 millimeters long, joined to a small column of vulcanite in which a little steel hammer is suspended. The lever of the hammer can be depressed to a certain point, and when liberated the hammer falls upon the cylinder and sets it into vibration. The instrument is tuned to C^2, and it gives a note of constant intensity and pitch, and louder than ordinary watches. It is heard, on the average, about 15 meters distant. There is a pin fastened to the column, holding a small metal disc on its end. This disc is placed against the skull if it is desired to use the instrument for testing bone conduction.

It is important to compare the *aërial* and *bone* conduction with the tuning-fork. The normal ear hears the sound of the fork C^2 better through the air than through the bones. When the auditory nerve is predominantly affected, the fork is almost always heard worse through the bones than through the air; when the middle or external ear is the chief seat of disease, it is heard best through the bones. A convenient method of testing is to hold the vibrating fork for a few seconds on the mastoid bone, and then opposite the external meatus, and let the patient say in which position it sounds loudest. A more exact method is to hold it in one of these two positions until its sound ceases to be heard, and then transfer it instantly in the other position; if the sound is now perceived again, it proves that conduction is better in the latter position than in the former.

The chief reason why a tuning-fork held on the teeth or the vertex is heard better in the deafer ear, when the deafness is due to disease in the conducting portions, is that the escape of the vibrations outward through the drum and auditory canal is *obstructed*—more of them are thrown back upon the nerve, and the latter thus perceives the sound intensified (Politzer). If, in such a case, the meatus is also plugged by the finger, the sound will be still further increased on that side. It is thought that, when plugging the canal in this way does *not* intensify the sound, this fact is proof that the auditory nerve is involved; this view is not held by all surgeons.

The tuning fork held on either parietal protuberance is heard better *in the opposite ear* in a normal case. This is still more noticeable if that ear is the seat of disease confined to the conducting portions.

Testing the hearing in one-sided deafness requires great care, owing to the difficulty in excluding the good ear. The following methods are useful:—

Stop the better ear and direct it toward the source of sound; then test the hearing with the deaf ear alternately open and closed; if there is any difference found by the two tests, the balance is credited to the worse ear (Dennert and Lucae, Berlin, nineteenth century).

Stop the affected ear and pass a vibrating tuning-fork back and forth alongside of it. If the sound is not increased as the fork nears the meatus, it is concluded that the sound has been heard through the good ear (Knapp, New York).

Stop the good ear, turn the affected one toward the source of sound, and test the hearing; then test it again with the affected ear also stopped; if there is no difference, the conclusion is that the affected ear is totally deaf, and that the sound reached the auditory nerve of the good ear through the bones. But if stopping the affected ear makes the hearing worse, repeat the tests, nearer, until they are heard again. The difference between the hearing distance by the first test and the second will represent the loss caused by stopping the affected ear, consequently that ear's hearing distance by aërial conduction (Burnett, Philadelphia).

The condition of the nasal and pharyngeal mucous membrane should always be examined. Rhinoscopy and laryngoscopy are of great assistance. The present condition of the general health and inquiries as to past illnesses are very important.

Examination of Auditory Nerve.

For examining the EXTERNAL AUDITORY CANAL and MEMBRANA TYMPANI an aural speculum and mirror are

necessary. The end of the speculum is inserted about $^1/_4$ inch into the meatus and held between the thumb and forefinger of one hand; at the same time the upper edge of the auricle is held between the same forefinger and the middle finger. In this way the auricle can be pulled upward and backward, which obliterates the curves of the canal, and allows a clear view to the bottom of it. The parts are illuminated by the otoscope,—a round, concave mirror about 3 inches in diameter, with central perforation,—which is held close before the observer's eye at a distance of from 6 to 10 inches from the patient (Hoffman, von Tröltsch). Either daylight or artificial light may be used; the former is simpler, and may be used when artificial light is not to be had.

When both hands are required for examination or for making applications the mirror is held on the forehead by an elastic band passing around the head. Some prefer a band without elastic in it, which can be buckled to suit the size of the head. This holds the mirror steady and firm.

THE EUSTACHIAN CATHETER and POLITZER'S METHOD OF INFLATION are used to introduce air into the middle ear through the Eustachian tube. Their diagnostic use is to show whether the tubes are pervious and whether the predominating elements of disease are such (catarrhal) as can be relieved by inflation. If so, the patient will feel the puff of air enter the ear, the drumhead will probably be pushed outward and congested, and hearing will be improved. To introduce the catheter:—

1. Have the instrument warm and moist.

2. Let the patient hold his head in a natural position and have him blow his nose to moisten the nostril, or better, use an atomizer with Dobell's solution.

3. Place the forefinger of one hand on the patient's upper lip and stretch it downward.

4. Hold the catheter lightly with the other hand near its large end and in vertical position, with the ring or other mark on its handle pointing toward the median line. Then introduce its curved beak gently into the nostril corresponding to the ear under examination, and as soon as it has fairly entered the nose raise the handle into the horizontal position and push the catheter very gently back, with its beak hugging the floor of the nostril, until it is felt to strike the hard posterior wall of the pharynx.

5. Withdraw the catheter about $^1/_4$ inch, rotating it a little more than one-quarter on its axis so that the ring on its handle points toward a point halfway between the external auditory meatus and the external canthus of the eye, when the top will generally fall opposite the orifice of the tube. If the catheter is in the proper position, it will not be disturbed by the patient's talking or swallowing. It may be steadied by resting the fingers against the patient's nose, while air is forced through it from an ordinary airbag. Difficulties in introducing the catheter are generally due to its being held in a wrong position, so that it enters the middle meatus of the nose; and to the patient's spasmodically contracting his facial muscles so as to prevent the necessary relaxation of the parts. Sometimes the manipulation is made difficult or impossible by a very crooked or occluded nostril. The instruments usually found in the shops are of too large caliber, and have too great a curve, to be readily introduced except by the most experienced. There is no advantage in an instrument of too large a caliber or with too great a curve. Hard rubber instruments are preferable to those of metal (Politzer).

POLITZER'S METHOD OF INFLATING THE MIDDLE EAR (Adam Politzer, Vienna, nineteenth century).—This consists in forcing air through the nostril and Eustachian tube during the act of swallowing, which opens the tube. The uvula and soft palate are at the same time brought against the pharyngeal wall and the upper wall is shut off from the lower pharyngeal space. The patient takes a little water in his mouth and holds it until a given signal. The nozzle of an airbag is then inserted into his nose and both nostrils tightly squeezed together around it. A signal is then given, and, as the patient swallows the water, the airbag is compressed and air forced in. When it is very difficult to make air enter the ear, it may often be done easily by mingling a little chloroform vapor with it. This is done by putting a few drops of chloroform (Prout) on the little sponge contained in the box attached to Politzer's apparatus (Roosa) now generally used. For children, Politzer's method may be used by means of a simple piece of rubber tubing through which air is blown directly from the surgeon's lungs. Or the bag may be used while the child is crying, when the tube is well opened.

VALSALVA'S METHOD, OR THE VALSALVIAN EXPERIMENT (Valsalva, Italy, seventeenth century).—This consists in taking a deep inspiration and then forcing the air outward so as to distend the cheeks and inflate the ears, while the mouth and nostrils are kept tightly closed. Its frequent use congests the ears and relaxes the drumhead, and, being inferior to the other methods, it should not be advised.

Bougies are passed through the catheter to examine for strictures of the tube by some authorities and electricity is passed by means of bougies. It is very doubtful if as good

results are obtained by this method as by the use of vapors or fluids through the catheters.

Several useful modifications of Politzer's method of inflation have been proposed. Gruber (Vienna, nineteenth century) recommends that the patient, instead of swallowing water, say *hic, haec,* or *hoc;* Dr. Tansley (New York) that he blow forcibly with puckered lips; and Dr. Holt (Portland, Me.) that he close the lips tightly and distend his mouth and cheeks with air at the moment when the airbag is compressed. Another method is to cause the patient to blow as if blowing out the light of a candle at the moment the operator presses the airbag.

For the successful performance of Politzer's method it is important that a good airbag, one of a good quality of India rubber, be used. A bag constituted of poor, thin rubber is almost useless.

CHAPTER VII.

GENERAL REMARKS ON THE CHIEF METHODS OF TREATING DISEASES OF THE EAR.

Syringing the Ear.

There are needed for this very common and important means of treating the ear, a metal syringe that can be readily sterilized (holding 4 to 6 ounces) with a bulbous nozzle, a bowl to hold the water, and a lighter one (such as a finger-bowl) to catch it. The patient, being seated, holds the small bowl under the auricle and pressed firmly against the cheek, to prevent the water from running down his neck. The operator should straighten the canal by pulling the auricle up and back with one hand, and, placing the nozzle of the syringe well into the meatus, should then gently force the stream down to the bottom of it. As a rule, only simple sterilized water should be used, and as warm as can be borne comfortably.

Irrigation.

The aural douche is used in acute inflammation where a *steady flow* of warm water is required—irrigation. The douche consists of a cup or rubber bag to hold the water, with a piece of rubber tubing attached. The cup or bag is placed above the head so that the water runs through the tube and into the ear from its own weight. The force of the stream may be regulated by the height of the cup, and should be very gentle. An ordinary fountain syringe makes a very convenient douche.

If all syringing causes pain or vertigo, water may be dropped into the ear from a spoon; or absorbent cotton twisted on a cotton-holder may be used to clean the ear. The COTTON-HOLDER is simply a slender steel probe around whose end a little cotton can be tightly wound. It is used to cleanse the ear and dry the deep parts of the ear and to make applications to them. The cotton should be absorbent.

LEECHES.

LEECHES, in inflammations of the external auditory canal or middle ear, should be applied at the base of the *tragus,* on the front wall of the canal, or on the mastoid process, for the reason that at these points the blood-vessels which supply the diseased parts are most conveniently and surely reached. Cotton should be placed in the meatus to keep the leeches from crawling in. By using a leech glass and scratching the skin to draw a little blood, the leech can be applied to the exact spot desired. After-bleeding should be encouraged for an hour or more, after which it can be checked with styptic cotton or a compress and roller bandage if necessary.

BLISTERS.

BLISTERS BEHIND THE EAR are usually only of use in chronic inflammation. In acute attacks, where prompt measures are needed, they generally add to the patient's discomfort.

POULTICES.

POULTICES IN THE EAR are injurious, as a rule. In acute inflammations they tend to make the tissue edematous and to favor its breaking down. If ever needed to quiet pain, they should be of conical shape, small enough to be

pushed into the meatus, and only applied for a short time. It is sometimes necessary to use poultices in front and behind the ear, but not upon the auricle, to alleviate the pain of severe inflammations. A saturated solution of the acetico-tartrate of alum is a better application than an ordinary flaxseed poultice. Menthol and glycerin plugs made of absorbent cotton are often very useful applications in the auditory canal.

MEDICATED SOLUTIONS to be dropped into the ear should always be warmed. This is easily done by holding them in a spoon or test-tube over a flame or the bottle in hot water.

THE ICE COIL.—This is highly esteemed by some authorities as a means of aborting mastoid disease. Leiter's coil is the best. The ice coil should never be used for more than forty-eight hours, and, as a rule, twenty-four is sufficient. The great danger of the ice coil lies in *masking* the true condition of affairs.

PARACENTESIS OF THE MEMBRANA TYMPANI.[1]

The pernicious practice of puncturing the drum-membrane in acute or chronic catarrhal inflammation of the middle ear in every case with redness of the membrane and slight effusion in the middle ear is to be condemned in no uncertain words. In no case when there is no bulging of the membrane should a paracentesis of the drum-membrane be made until douching of the canal with hot water (90° to 120° F.) has been thoroughly applied, and leeching in front and back of the ear resorted to, besides opening the bowels with calomel and soda. After this, if the pain persists with increased temperature and the drum-

[1] Riolanus, Paris, 1650.

membrane is bulging outward and is very red, paracentesis should be performed, but not until then.

The experience of Dr. Buck[1] in these cases is so much in accord with ours that we give it here:—

"In former years I followed, for a time, the practice of always incising the drum-membrane and evacuating the fluid, as soon as I discovered a sufficient amount of it in the tympanum to apparently half fill that cavity. I very soon found, however, that relapses were exceedingly frequent. I accordingly modified the rule to this extent: I postponed making the incision and evacuating the fluid until after I had materially diminished the naso-pharyngeal catarrh and had re-established a passage through the Eustachian tube. Under this *régime* I observed now and then a case in which the fluid contents of the tympanum gradually disappeared coincidently with the improvement in the condition of the naso-pharynx, thus rendering paracentesis unnecessary. This suggested to me the idea that the treatment employed in the ordinary cases of catarrh of the middle ear, without effusion, would probably be found equally successful in those with effusion. I accordingly dismissed from my mind the idea that paracentesis was either necessary or desirable, as a means of getting rid of the effusion in the tympanic cavity, and adopted the practice of treating these cases in precisely the same manner as I do the ordinary cases, in which there is no appreciable amount of effusion. I have followed this practice now for many years and am well satisfied with it. It is only in rare cases now that I yield to the temptation to make an incision and evacuate the fluid, and even in some

[1] "Text-book of Diseases of the Ear," third edition, page 228.

of these I have afterward arrived at the conclusion that the case would have got well just as quickly if I had not had recourse to the knife."

An unnecessary paracentesis of the drumhead in acute *otitis media* may render the tympanum more septic than before and is sometimes more dangerous than a simple opening of the mastoid cells.

METHOD OF OPERATION.—This operation can be performed without causing the patient any pain if the following formula is used: Mix equal parts of the crystals of cocain, menthol, and carbolic acid; add a drop or two of distilled water and allow to stand a few minutes. Apply directly to the drum membrane with cotton wrapped on a carrier or probe. After eight minutes' waiting proceed with the operation. The membrane can then be pierced at any point desired. The best point is to begin the incision posteriorly near the periphery of the membrane, on a level with its center, and make a curved incision downward and forward to the middle of the anterior inferior quadrant. In this way we avoid injuring the long process of the incus and the stapes. After making the incision it is usual to inflate the ear gently by Politzer's or the Valsalvian method. This opens the wound and tends to force out any matter which may lie in the tympanic cavity. The external auditory canal is then *very gently* dried with cotton on a carrier, and packed also gently with sterilized gauze and held in position with a bandage. This may be changed several times a day in order to irrigate the canal with hot water if pain persists. A Graefe cataract knife is a very convenient paracentesis instrument.

Excision of the Ossicles.

In cases of chronic suppuration which do not readily yield to ordinary treatment, when the ossicles are presumably or positively carious, and a septic condition of the tympanum persists in spite of careful treatment, they should be removed. The operation should be performed, as a rule, under a local anesthetic. Adrenalin solution will be very useful in checking the bleeding during the steps of the operation. A thorough curetting of the tympanum is sometimes very advantageous, the object being to remove granular tissue.

Aids to the Hearing.

Hearing Trumpets.—The different kinds of hearing trumpets, or ear trumpets, that have been invented are too numerous even to mention. The most satisfactory of them all, so far, is that invented by Dr. Maloney, of Washington, and called the otophone. It is made of hard polished rubber and is composed of two pieces—a short trumpet, 2 to 3 inches in diameter at the wide end, 2 to 4 inches long, and curved almost at a right angle at the smaller end to screw into a disc somewhat like that on a telephone receiver. In the center of this disc is a small opening about $^1/_2$ inch in diameter covered with a diaphragm. The whole instrument is very compact, and can be held to the ear with the hand just as a telephone receiver, or on a handle, or by a clasp over the head. Two advantages of the instrument over the older ear trumpets are (1) the earpiece rests against the ear and does not fit into the external auditory canal as do the old instrument, which latter have often irritated the canal; (2)

the diaphragm in the earpiece prevents the roaring metallic sound heard in the ordinary ear trumpets, and lessens, in a great measure, the reverbations of loud sounds. For very deaf people a flexible tube about 3 feet long and 1 inch in diameter, with a mouthpiece for the speaker, is furnished. The instrument is not very expensive, costing only about $10.00.

Recently, two other instruments, the akouphone and the akousticon, have been placed before the public with much newspaper notoriety. They are fashioned somewhat on the order of an ordinary telephone, and consist of a receiver, a transmitter, and an earpiece, like that of a telephone. In addition, a small electric battery is necessary to their working. While they have proved of great benefit to a few people, they are very costly, are often out of working order, due chiefly to the electric battery, which is necessary to their proper use, being out of order, and withal are not always as satisfactory as the simpler and less expensive instruments. They should be subjected to a thorough trial by the person using them before purchase.

The above instruments aid hearing through aërial conduction. The following described instrument aids the hearing by means of bone conduction:—

THE AUDIPHONE.

The audiphone was invented by Mr. R. S. Rhodes, of Chicago, Ill. It consists of a thin and elastic diaphragm of hard rubber fitted to a handle, so that the whole looks much like a fan. The upper edge of the diaphragm is bent toward the lower by silken cords attached to it so that a convex surface is presented toward the source of sound, and a concave

one toward the listener. The tension of the diaphragm can be regulated by the cords as best suits each case. In using the instrument, the upper edge is pressed firmly against the central incisors or the eye teeth of the upper jaw. An ordinary palm-leaf fan sometimes serves well as an audiphone.

CHAPTER VIII.

DISEASES OF THE EAR.

AURICLE.

INJURIES.

INJURIES of the auricle are of various kinds, and require careful treatment, since the auricle is very poorly supplied with blood. CHONDRITIS is apt to result from blows upon the auricle. This is apt to be a tedious affection. The initial swelling may be treated by wet applications. One of the best is a saturated solution of acetico-tartrate of alum. When the acute symptoms have subsided, oily applications are appropriate—sweet oil, vaselin, lard, or the like. If the tension and swelling are very great, incisions entirely through the tissue are necessary. It is very difficult to prevent deformity if the inflammation is considerable.

ECZEMA.

ECZEMA of the auricle is quite common, and is generally associated with eczema of the external auditory canal. It presents the same appearance as elsewhere and requires the same treatment. The use of water in the ear is to be avoided.

ERYSIPELAS.

This may originate in wounds or ulcers behind the ears, and invade the auricle. It sometimes occurs after operations upon the mastoid as well as independently. The lead and opium wash and one of aluminum acetico-tartrate

acts well. It is usually not dangerous, and requires the same treatment as facial erysipelas in general.

The auricle is subject, also, to *erythema, herpes, syphilitic eruptions, frostbite,* and so forth. If any cold fluid is used in the treatment, it should not be allowed to run into the auditory canal, lest it excite inflammation of the deeper parts of the ear. In cases of frostbite it is necessary to guard against too sudden reaction; the auricle should be bathed with very cold water at first, and warmer applications made very gradually.

TUMORS.

TUMORS of the auricle comprise: *(a) Fibrocartilaginous;* simple hypertrophies. They are most frequent among negroes, and often result from the irritation of piercing ears for earrings, especially where brass or other septic earrings are worn. They may be removed by a V-shaped incision, the edges of which are afterward united by sutures. *(b) Sebaceous.* These may be enucleated. *(c) Erectile.* These are best treated by the galvanocautery. *(d) Othematoma,* or *vascular tumor;* idiopathic and traumatic. In the former the ear becomes red, swollen, and hot, and then effusion of blood occurs, chiefly in the concha, obliterating the folds of the auricle, and causing a painful, roundish tumor, of variable size, in which fluctuations may be found; the effusion may be absorbed or the tumor may rupture or suppurate. Such tumors are supposed to be due to cerebral congestion and centripetal irritation from the emotions; they are most common among the insane. Some advise noninterference, others opening and evacuating the sac and using a pressure bandage. We prefer judicious incisions. After recovery

great deformity is apt to result. The traumatic form is simple extravasation from vessels ruptured by violence, most common among porters and is due to their occupation, and is not apt to leave a deformity.

MALIGNANT DISEASE is very rare as a primary affection of the auricle. Epithelioma and lupus are the two usually met with. Treatment by the x-ray should be tried first. Failing in this, removal by operation is the proper remedy.

MALFORMATIONS may be congenital or result from ill treatment (such as allowing the hat to press against the auricle, etc.) or disease. Ears thus lopping over are benefited by a plastic operation, consisting essentially of an excision of a part of the auricle at its union with the canal. The auricle may be congenitally absent or rudimentary, generally with some defect of the deeper parts. It is said that an auricle has been transplanted from one patient to another with success (?). Supernumerary auricles have been observed. Horny growths rarely (Buck), and cleft lobules are occasionally seen.

DEPOSITS OF URATE OF SODA are often found on the auricles of gouty subjects, especially on the helix, sometimes causing considerable pain.

IDIOPATHIC CHONDRITIS AND PERICHONDRITIS OF THE AURICLE.

These diseases consist of an inflammation extending from the auditory canal to the auricle. The inflammation is very painful and is very sure to leave considerable deformity. Cooling applications or fomentations should be used, according to their effects. Free incisions are to be made to secure good drainage. Iodoform gauze is a good dressing after incisions are made.

DIFFUSE INFLAMMATION and ABSCESSES of the auricle, from whatever cause, require careful attention, as they tend to produce great deformity.

EXTERNAL AUDITORY CANAL.

FOREIGN BODIES.

These include insects and their larvæ, and such articles as beads, buttons, peas, beans, and so forth, which are thrust into the ear, especially by children. Insects sometimes fly into the ear, causing agonizing pain. Syringing with warm water usually brings them out at once. If this be not readily affected in a case of peas and beans and other vegetable matter it is better to syringe the ear with equal parts of alcohol and water, or even pure alcohol, as this *contracts* them and does not make them swell, as does water alone. Insects are readily attracted by the odor of a suppurating ear to deposit their larvæ upon the pus within it; larvæ may cause pain, or only discomfort, by their wriggling motions. Examination of an ear so affected shows small, white, wormlike animals moving rapidly about; they are provided with hooks, by which they cling to the tissue. They cannot generally be dislodged by syringing, unless some parasiticide has first been used. Labarraque's solution, chloroform vapor, and carbolic acid solution are used for this purpose, generally with success; sometimes forceps are necessary. Beads, buttons, and so forth are chiefly dangerous through indiscreet efforts to remove them; through such attempts the ear and even the life of the patient have been destroyed. Beans, peas, and so forth are troublesome, because they swell after being in the canal for some time. In treating these cases the first thing

to do is to examine the ear with the otoscope. Never try to remove a foreign body which you cannot see. In ordinary cases simple syringing will suffice. If the foreign body is impacted, and there are inflammation and swelling about, it is better to wait, meanwhile practicing very frequent irrigation with hot water until the latter subside. If instruments become necessary, the patient should be etherized and the foreign body dislodged by forceps or probe and then removed by syringing. The value of patient and gentle manipulation cannot be overrated. If the foreign body is causing no bad results, there need be no haste about its removal. If instruments really become necessary, they should only be used by a practiced hand. Foreign bodies sometimes penetrate into the tympanum, but require no different treatment from that given above. It may become necessary to detach the auricle from the canal posteriorly, in order to get at a foreign body in the tympanum.

INSPISSATED CERUMEN, OR HARDENED WAX.

This is quite often found in the auditory canal. In the majority of the cases it is probably secondary to some other affection of the ear, and should be so considered when complete relief of symptoms does not follow its removal. Wax is not removed by motions of the jaw, as it normally is, but collects in the canal, its watery parts evaporate, and a brown or black mass is left, sometimes as hard as stone.

The symptoms are impairment of hearing, *tinnitus* (Latin for ringing), sense of fullness, vertigo, and pain—the two latter symptoms being rather infrequent. The loss of hearing usually comes on suddenly because it does not occur until impaction takes place, although there may be a

great deal of wax present. Impaction may result from any sudden jolt or jar. The wax is easily seen with the otoscope as a dark mass filling the canal.

Simple syringing with warm water is the best method of removing the wax, and is usually sufficient. Sometimes, where the wax is very hard, a solvent, such as a solution of soda bicarbonate (gr. x to ℥j) must be dropped into the ear several times for a day before the syringing will be successful. Several sittings may sometimes be needed to remove the wax, and they are preferable to doing too much at once. Probing may be necessary to loosen the mass and break up its hardened surface so that syringing may be effectual. Instruments should be avoided, however, if possible, except in practiced hands. All the wax should be removed, as even a small piece left upon the drumhead will keep up the unpleasant symptoms. Where the hearing is normal after removing the wax, a little cotton should be kept in the ear for a day, otherwise sounds will be unpleasantly acute, and the shock of them may injure the ear. Where the hearing is not normal after the wax has been removed, inflation will gradually improve it, for in such a case there is likely to be disease of the middle ear.

DIFFUSE INFLAMMATION.

Diffuse inflammation is quite rare. It is caused by local septic irritation, such as earpicks, dropping of oil into the ear, and so forth, and, rarely, by exposure to a cold draught. The symptoms are itching, followed by pain, sense of fullness, and, perhaps, some impairment of hearing. The canal and membrana tympani are red and swollen, and the epidermis and integument may suppurate. Where the skin

is closely adherent to the bone, the pain is intense and the disease is essentially a periostitis.

The treatment in the acute stage comprises leeching, incisions, and warm douches, and, if these fail, poultices. If suppuration is established, the ear should be thoroughly cleansed every day by syringing with warm water and astringents applied. A solution of alum or zinc (gr. $^1/_4$ to ℥j) may be dropped into the ear by the patient, after syringing. The surgeon should cleanse the ear himself three or four times a week, and make some appropriate applications to the affected part.

FURUNCLE.

Circumscribed inflammation, or furuncle, is often a symptom of a wrong state of the system—an infection of some kind. It is apt to occur in anemic persons and to be recurrent. It is not an uncommon complication of subacute suppurative inflammation of the middle ear. The affection is painful, and may lessen the hearing by filling up the canal. It does not usually cause tinnitus. The proper treatment is to make a thorough incision through the swelling as soon as possible, whether pus has formed or not, and then to use the warm douche freely. A probe is useful to find the most tender point when the furuncle is not very marked. The incision is best made with a sharp-pointed bistoury, and should be a deep and free one. Leeches are not of much service. A small cotton tampon saturated with glycerin is useful as a continuous application to the canal. Carbolic acid, followed by alcohol, is a beneficial application (S. D. Powell).

ECZEMA.

This is generally associated with eczema of the auricle. The swelling of the canal causes fullness and tinnitus, with loss of hearing at times. The disease is rarely brought to notice until it has become chronic.

In the treatment the first requisite is a thorough removal of exuded matters every day, and this is best done by the surgeon himself. At the first visit the warm douche should be used thoroughly to cleanse the affected parts. After this no more water should be used. The patient should be seen every other day and the scabs and scales removed by means of a little cotton wrapped on an applicator. The cotton may have vaselin on it so as to soften the exudate on the ear. After cleansing, zinc oxid ointment is to be applied. Where this fails we have found the following tar ointment almost without fail to give relief:—

℞ Liquor picidis	ʒj.
Hydrargyri oxidi flavi	gr. viij.
Vaselini	ʒij.
Lanolini	ʒj.

M. et ft. unguentum.
Sig.: Apply on alternate days after cleansing the parts.

Arsenic is generally useful internally, and, where there is any specific history, hereditary or acquired, antispecifics are to be used.

VEGETABLE FUNGI (OTITIS PARASITICA).

These are sometimes germinated in the auditory canal and cause or aggravate inflammations of the part. They are most commonly secondary to eczema. The symptoms of

otitis parasitica are: tinnitus, fullness, deafness, dull pain, vertigo, whitish or blackish flakes adhering to the walls of the canal and outer surface of membrana tympani, and blocking up the passage. The latter require forceps for their removal, and the tissue beneath them is found red and tender. The growth may reappear in a few hours. The varieties of parasites are:—

1. *Aspergillus* { *flavus.* / *glaucus.* / *nigricans.* }
2. *Penicillium glaucum.*
3. *Graphium penicilloides.*
4. *Tricothecium roseum.*

They can only be seen by the microscope. The treatment consists in keeping the canal free from fungi and subduing the inflammation. Many parasiticides are recommended, but the warm douche, thoroughly used, is as good as any. Nitrate of silver and argyrol are among the best applications. Aspergillus is frequently seen in humid climates, such as the Philippines. Inflammation of the canal is treated as usual.

POLYPI.

These result from prolonged or violent suppuration, or one that has been augmented by poultices so that the integument has been destroyed by an ulcerative process. Usually they are associated with polypi of the middle ear and require the same treatment—that is, thorough removal, with the subsequent application of carbolic, nitric, or chromic acid or alcohol.

Syphilitic Ulcers and Condylomata.—These are very rare. They require local cleanliness and the proper internal remedies for syphilis.

Exostoses and Hyperostoses, or Bony Growths.—These sometimes occur in the osseous part of the auditory canal. Most frequently they come from a chronic suppuration of the middle ear, extending its irritation to the canal, and will therefore be considered under that section. They may be congenital or occur in some special diathesis. If the canal is occluded by growth, an operation for opening a passage through it by means of a drill, or removing it by means of chiseling must be performed.

Cysts.—As a primary growth these are rarely found in the external auditory canal. When present they should be incised and the sac curetted. They may be filled with sebaceous material or be of gouty origin, when lime deposits may be found.

Myxofibroma as a primary growth in the external auditory canal is exceedingly rare. They should be removed by excision.

Sarcoma and carcinoma have been observed but rarely in the external auditory canal as primary growths, but a few cases being on record. Their treatment is the same as when found in other parts of the body. The x-ray treatment is likely to be useful here.

Diseases of the Middle Ear.

INJURIES OF THE MEMBRANA TYMPANI.

The drum membrane is subject to injuries from concussion, from effects of condensed air, from foreign bodies,

instruments, and so forth. The membrane has been ruptured from artillery explosions, but not with relative frequency; also from exposure to condensed air, as in caissons used in building bridge piers; from blows upon the side of the head; from waves striking the side of the head in sea bathing; from violent vomiting, coughing, and blowing of the nose; from hairpins, blades of straw, and so forth, thrust into the ear; from use of instruments to remove foreign bodies and wax. Where there is disease of the ear and collections of mucus in the tympanum and Eustachian tube, the drumhead is much more liable to rupture from all the nontraumatic causes than where the parts are healthy. Rupture of the drumhead in suppuration of the middle ear is discussed under that section. To determine the nature of a rupture, it should be seen soon, before suppuration has had a chance to occur around it. Traumatic ruptures are apt to heal promptly, without suppuration, and to leave the hearing intact. Those from concussion are serious, as deeper parts are generally injured at the same time.

Treatment.—Above all, the ear should not be disturbed by syringing or otherwise immediately after the injury. If inflammation and suppuration appear, they should be treated as in acute inflammation of the middle ear. Meanwhile the ear should be protected by a bit of sterilized gauze placed in the meatus, and the patient kept under careful, but not meddlesome, observation.

MYRINGITIS (Lat. *myringa*), OR INFLAMMATION OF THE DRUMHEAD, is only part of an inflammation of the adjacent regions. The anatomical structure of a membrane which has no independent nutrition, which has but one layer of tissue peculiar to itself (and that in its center), but which

is a direct continuation of the neighboring parts, rather precludes the idea of its being primarily diseased.

FRACTURE OF THE HANDLE OF THE MALLEUS is very rare. The diagnosis in these cases is based upon the peculiar irregular appearance of the bone. (Weir.)

ACUTE CATARRH.

ACUTE CATARRH of the middle ear is quite common. It has many causes, such as exposure to cold and wet; allowing cold water to run into the ear; "colds in the head"; constitutional diseases, such as scarlet fever, measles, small-pox, pneumonia, syphilis; use of the "nasal douche"; sniffing of water up the nostrils; operations upon the nose, and so forth. The danger from the nasal douche is probably due to the entrance of some of the water through the Eustachian tube into the tympanum. Acute catarrh generally starts from the faucial end of the Eustachian tube, but may sometimes extend from the external auditory canal. The symptoms are pain; sense of fullness; tinnitus; impairment of hearing; injection, swelling, and bulging outward of the membrana tympani; catarrh of the pharynx and Eustachian tube; fever, and, rarely, delirium.

The pain is usually intense. The familiar "earache" is identical with acute catarrh. In children too young to speak it may be difficult to locate the pain. Pressure against the tragus to see if the child winces, and dropping warm water (or even breathing) into the ear to see if it quiets the pain, are useful diagnostic tests. Sensations of fullness may precede pain or follow it. The tinnitus in acute catarrh generally assumes the form of a *beating,* or *puffing,* in the ear, and is distressing. Deafness may not be marked in the

stage of pain; indeed, hearing sometimes seems more acute than normal. Redness of the membrana tympani may be confined to the periphery and along the malleus handle, or be intense over the whole membrane, effacing all its normal appearances. Bulging outward of the membrane may often be seen after the first forty-eight hours of the attack, generally in the posterior part and in Shrapnell's membrane. Fever is often and even delirium is sometimes present.

The *treatment* should be antiphlogistic and prompt. The patient should usually be kept indoors and in bed. The first remedy in efficiency is local bloodletting by the application of from 1 to 4 leeches to the tragus. The next is warm water poured into the ear by the douche so as to give it a continuous bath (irrigation). The douche may be used for several minutes every half-hour. Poultices should only be used when other measures fail, as they are dangerous to the integrity of the drumhead. Dropping of oils, molasses, and so forth, into the ear is useless, and only clogs up the canal. Codein may be given internally. If local treatment be prompt and thorough, anodynes will not often be required, and they should not be used in the first instance. If perforation of the membrana tympani is threatened a paracentesis should be performed. If the mastoid region becomes involved, an incision should be promptly made down to the bone, and if necessary the bone opened. Inflation is advisable when acute symptoms are beginning to subside, to blow out the secretion and prevent adhesions. Cocain *freely* instilled is sometimes useful. The naso-pharynx should be looked after carefully and silver nitrate solution (3 to 4 per cent.) applied. A gargle of very hot water should be used every hour or even oftener, and a 20- to 50-per-cent. solution of argyrol once a day.

Such prompt treatment generally results in a perfect cure, saving the patient from chronic otitis and its evil consequences. If suppuration occurs, it is usually tractable.

Several cases of acute catarrh have occurred in which the course was very rapid, ending in perforation without suppuration, but with abundant hemorrhage through the drumhead within five hours after the first symptom. In other cases of acute catarrh, where a paracentesis has been done, only blood has escaped from the tympanum—a spontaneous hemorrhage in the midst of acute pain.

The name given to such cases is *otitis media hæmorrhagica* (Roosa). (Hemorrhage into the middle ear may also occur from atheromatous vessels, as in kidney disease.) Sometimes *exudations of serous fluid into the tympanum* (hydrotympanum) occur without any active inflammatory symptoms. The patient complains of not hearing well, of a sense of stiffness, and perhaps of pressure. On inspection, the level of the fluid may be seen through the drumhead, and this may alter with a change in position of the patient's head; or bubbles of fluid may be seen behind the membrane; or there may be nothing evident save some slight alteration in the translucency of the part. Inflation, paracentesis, and attention to the throat and general condition are the chief means of treatment.

SUBACUTE CATARRH.

This is common in children and young persons. It is distinguished from acute catarrh chiefly by its milder course and by the absence of severe pain. The patient is subject to periods of marked loss of hearing, a sense of fullness and tin-

nitus, the membrana tympani may be congested or not, and the pharynx is catarrhal. The pathological changes are probably plugging of the Eustachian tube and tympanum by mucus, without structural changes.

Treatment.—It will generally be found that the patient is badly managed, and needs proper hygienic care—such as regulation of diet, attention to the skin, proper exercise, and so forth. Tonics and attention to the pharynx are important. The best application to the pharynx is a solution of silver nitrate, 3 per cent., or argyrol in solution, 50 per cent. The use of the catheter (except in children) and Politzer's method, generally restore the hearing—in some cases almost immediately. Inflation should be kept up daily. Particular attention should be given the pharynx as to the existence of adenoid growths and enlarged tonsils. These should be removed if found, but the hearing may be usually improved or made perfect for a time without the treatment necessary to prevent a repetition of these attacks.

The nonsuppurative inflammations are described separately for convenience, but it must be remembered that in practice the line of separation between them is not always well marked:—

CHRONIC CATARRH OF THE MIDDLE EAR.

This disease forms a large proportion of the cases presenting themselves for treatment. It is either a consequence of acute catarrh or supervenes upon chronic catarrh of the nose and throat, especially in constitutions enfeebled by disease or faulty hygiene. The patient has the usual symptoms of chronic naso-pharyngeal catarrh. In addition he has occasional sounds in his ear like the crackling of air-bubbles;

a sense of fullness; tinnitus; deafness; sometimes vertigo. *Tinnitus aurium* is a very trying symptom, and sometimes causes great depression, even resulting in the patient's suicide. The noises in the ear and head are variously described as buzzing of insects, rushing of water, ringing of bells, and so forth. There are also changes in the membrana tympani, and imperfect action and changes in the structure of the Eustachian tube. The appearances of the drumhead are valuable in connection with other signs, but they are not always diagnostic, as many of them may also be seen in ears with normal hearing power. A sinking inward of the drumhead rarely occurs without impairment of hearing. It is shown by an unusual prominence of the short process of the malleus, with altered position of the handle; by diminution, irregularity, or absence of the light spot; and by a generally collapsed or sunken appearance of the membrane difficult to describe. There may be a loss of the normal luster of the membrane, with opacities and calcareous deposits in it. It may have lost its natural mobility from adhesions or be preternaturally mobile. This may be tested while the patient performs Valsalva's experiment or by Siegle's otoscope. The changes in the pharynx and the Eustachian tube are usually marked. The former presents the familiar appearances of chronic catarrh. Often it is studded by small, round elevations, constituting *pharyngitis granulosa,* or by adenoid vegetations in the young. Rhinoscopic examination shows similar conditions about the mouth of the Eustachian tube. The Eustachian catheter is valuable as a *sound* for determining the condition of the nasal mucous membrane as to swelling, polypi, and so forth, and for testing the permeability of as well as for treating the Eustachian

tube. The pathological changes in chronic aural catarrh, as shown by sections by Toynbee, Tröltsch, and others, are collections of mucus distending the tympanum, thickened mucous membrane, and filling of the cavity by lymph.

Hearing Better in a Noise.—This symptom occurs only in disease of the middle ear (Roosa). Patients with any form of disease of the middle ear uncomplicated by disease of the nerve always hear better in a noise, and not alone those who suffer from chronic incurable disease. The presence or absence of this symptom, which should be accurately and carefully determined without reference to the statements of the patient, becomes a valuable assistant in the differential diagnosis of disease of the middle or internal ear (Roosa).

Objective noises in the ear have been present in quite a number of reported cases. They are heard by the patient himself, and are also audible to others, sometimes at a distance of several feet. They are compared to fine mucous râles, or to the sound produced by snapping the edges of the finger-nails together, or by rubbing the hair between the thumb and finger close to the ear. They are usually accompanied by spasmodic contractions of the muscles of the soft palate and throat, and sometimes by simultaneous movements of the drumhead. In some persons they can be produced voluntarily. Some consider them due to contractions of the tensor tympani muscle. Most authorities think that they have their origin at the pharyngeal mouth of the Eustachian tube, being caused by a separation of the moist lips of that orifice. In one case they were thought to be due to spasmodic contraction of the stapedius muscle. Sometimes the hearing is normal, sometimes it is temporarily reduced while

the noises are occurring, and sometimes it is already permanently impaired. Often there is catarrhal disease present. The cause of the spasmodic twitchings of the muscle is obscure.

Treatment.—All needed measures for improving the general health are to be followed. Everything that renders the patient more vigorous and less likely to take cold will assist in relieving chronic aural catarrh. Attention to the skin, daily sponge-bathing and frictions, Turkish baths, and so forth, are very useful. Treatment of the pharynx and nose are very necessary. The nasal douche is dangerous as it has often caused acute inflammation of the middle ear, even when all precautions have been observed in its use. Recently, Dr. Beaman Douglass introduced a nasal douche which seems to be nearly free from danger to the ear. It consists of a rubber bag (of eight-ounce capacity) attached to a hard-rubber stem and nozzle, the latter large and cone-shaped to fit in the end of the nostril. A warm salt-water solution (ʒj to 1 quart) is most frequently used for cleansing the nose. This is sucked up into the bag, then the patient leans far forward, face downward over a basin, holding his head to the opposite side he is douching, and the solution is forced gently out of the bag into the nose. The soft palate is usually involuntarily drawn up, and the water runs out of the opposite nostril. Unfortunately at times water will go into the antrum of Highmore by this method.

The applications to be made to the nasal and pharyngeal mucous membrane will, of course, vary with different practitioners. For the nasal mucous membranes weak solutions of silver nitrate (gr. ii-v to ℥j) or zinc in the same strength may be used; or a solution of argyrol (gr. xxx-℥j) is

often beneficial and not irritating in the least. For the naso-pharynx, silver nitrate in solution (gr. x-xx to ℥j), applied daily or on alternate days, is the best remedy perhaps, and has not been displaced by the newer remedies. Also tincture of iodin and glycerin: ʒj of glycerin to ℥j.

A gargle is a matter of individual choice. A saturated solution of chlorate of potash is as good as any for ordinary purposes. Tröltsch's method of gargling is useful as a *gymnastic exercise* for the muscles of the tube, aside from its effect on the mucous membrane; the gargle is held in the back part of the mouth, the head thrown well back, and the nostrils closed with the fingers; swallowing motions are then performed without actually swallowing the solution. The Eustachian catheter is used for treating the tube and tympanic cavity. Simple air blown through it is most universally useful. Steam, weak solutions of iodin, nitrate of silver, zinc, and so forth, are also used. The vapor of tincture of iodin and camphor, ʒij of gum camphor to ℥j of iodin, is a pleasant and easy means of treating the tympanum through the catheter. Inflation of the middle ear by Politzer's method should be done every day or two. It is most effectual when used after the catheter. Whenever attacks of congestion or pain occur in the course of the disease, leeches, warm douches, and so forth, should be used. The nasal cavities may require especial treatment in the way of removing polypi, thickened mucous membrane, by cutting operations, by chromic or nitric acid, or by the snare. These operations are sometimes followed by acute inflammations of the tympanum. Chronic inflammations or deformities of the septum are not usually attended by aural disease, and operations upon the nose will not benefit the hearing of adults when it is impaired. Of

course, in obvious obstructions in the nose to breathing, operations should be resorted to. Operations on the nose are not so "popular," if we may use the term, as a few years back, when entirely too much cutting was practiced in the nasal cavity.

CHRONIC PROLIFEROUS INFLAMMATION (ROOSA).

In this form the symptoms, except the loss of hearing and tinnitus, are less positive than in the catarrhal form. There is but very slight or no pharyngitis, and the patient's history does not include infantile earaches, coryza, frequent colds, and so forth. It is found that the disease has begun and advanced insidiously, that it has got under full headway and essentially impaired the hearing before the patient noticed it. There may be no sign of catarrh, no closure of the Eustachian tubes, and nothing pointing to an excess of secretion in the pharynx, tubes, or tympanum, but rather to an opposite state of affairs. There are apt to be adhesions in the tympanic cavity, with a sunken and immovable drumhead. Often no cause can be discovered. Sometimes there has been a catarrhal inflammation which has long since passed away. In certain cases the disease seems to have some connection with pregnancy. At any rate, it then was first observed and may be aggravated at each subsequent pregnancy. Pathological changes found include adhesions in the tympanic cavity, ankylosis of the ossicles, atrophy and fatty degeneration of the tensor tympani, obstructions of the tube and the tympanum by dense fibrous tissue, hypertrophy of the bone, and so forth. This disease is sometimes confounded with disease of the labyrinth, or disease of the labyrinth may be coincident with or result from it. The

tuning-fork will materially aid in the diagnosis. If the bone conduction be better than the aërial, the disease is certainly in the middle ear.

Treatment.—This is like that of the catarrhal form, excepting that the pharynx does not usually need attention. In most of the cases of nonsuppurative inflammation a cure is out of the question, and the best that can be hoped for is to alleviate the condition or keep it stationary. Hygienic treatment should be kept up during the patient's life. Local treatment, if it does any good, should be given for from one to two months twice a year. For this purpose inflation by the catheter and Politzer's method and exhaustion of the air from the drumhead by Delstanche's *masseur* are the best means of treatment. Some cases progressively get worse in spite of every remedy. For inveterate cases which resist all ordinary treatment, maintaining a permanent opening in it and removal of the membrana tympani are sometimes performed. They are only to be undertaken by a skilled surgeon, and indications for them will be found in larger text-books. As a rule, they are not productive of much benefit. Electric massage is not useful. Treatment of the Eustachian tubes by bougies yields very poor results. It is no better than that by the vapors and fluids.

ACUTE SUPPURATION OF THE MIDDLE EAR.

This is usually a direct result of acute catarrh, and is preceded by its violent and painful symptoms. In many cases, however, the latter process is unobserved, and the discharge of pus is the first symptom noticed. In cases occurring from scarlet fever, measles, and so forth, the catarrhal stage is apt to be overlooked because of the grave symptoms of

the general disease. The causes are the same as those of acute catarrh, exposure to cold being the most common one. When the drumhead bursts the pain usually subsides. Sometimes pus escapes through the Eustachian tube, leaving the drumhead sound. Occasionally suppuration extends to the brain through the thin upper tympanic wall, or produces pyemia by entering the jugular vein.

Treatment.—In the early stages douching with hot water and leeching should be tried, and, if the membrane seems about to break, paracentesis should be done in the most bulging part. If the mastoid is red, swollen, and tender, an incision should be promptly made down to the bone *(Wilde's incision),* but generally if the external incision is necessary the mastoid bone should be opened. If the membrane has already ruptured, the ear should be cleansed of pus at least twice a day by syringing, after which a weak astringent, such as solution of zinc sulphate (gr. ii-℥j) may be dropped in. The ear should be cleansed and an astringent applied by the surgeon every day, if possible. Sometimes thorough cleansing, always with boiled water, without the use of an astringent, is sufficient. Politzer's method may be used gently every day or so, to blow secretions from the tympanum and prevent formation of adhesions. Under this plan the case usually progresses well, the membrane heals, and good hearing is restored. Acute suppuration is usually cured without either Wilde's incision or opening the mastoid.

CHRONIC SUPPURATION OF THE MIDDLE EAR.

This is commonly called otorrhea, or "running from the ear." It is sometimes mistaken for chronic suppuration

of the external auditory canal, which is very rare—a mistake which need never occur if the otoscope is used. The chief symptom is a purulent discharge. This may be profuse or scanty or only periodical. In the latter case a mass of dried pus may be found in the canal and the tympanum when the ear is examined. The drumhead may be swept away and the ossicles also; or there may be a rim of the membrane left, with one or more of the ossicles in place or dislocated; or there may be one or more cleanly cut holes in it, with the ossicles in position. Sometimes the perforations are very small and only detected by having air blown through it from the Eustachian tube, when the "perforation whistle" will be heard or a drop of pus be blown out through it. *Pulsation* at the bottom of the canal is suspicious, but not pathognomonic of perforation. It depends on a layer of fluid in contact with a beating blood-vessel. The pharynx and Eustachian tube are usually in a catarrhal state, and the general health below normal. The degree of improvement of hearing is variable, depending, as it does, on so many factors. The course of the disease is tedious and requires very patient treatment. In some cases suppuration never is permanently subdued. The anatomical relations of the tympanic cavity show the danger of allowing the disease to proceed unchecked. *Pulsation of the membrana tympani, without perforation,* has been observed in rare instances. A few cases have been reported where the pulsation seemed to depend upon a vascular growth in the tympanic cavity. Other symptoms present in these cases were redness and bulging of the drumhead, impairment of hearing, and an annoying, pulsating tinnitus, synchronous with the heart-beat.

Treatment.—The first requisite is *cleanliness.* The ear should be syringed once or twice a day, and should be cleaned by the surgeon himself as often as he may think best. Politzer's method is an aid in blowing secretions out of the tympanic cavity and breaking up adhesions. After cleansing, some astringent or caustic should be applied. If the perforation is small, an astringent solution may be dropped into the ear and allowed to remain a few minutes. If the drumhead is gone, a solution may be applied over the exposed surface by a cotton holder. Various solutions are used: zinci sulphatis, gr. $^{1}/_{5}$ to ℥j; argenti nitratis, gr. 10-480 to ℥j; cupri sulphatis, gr. $^{1}/_{5}$ to ℥j; aluminis sulphatis, gr. $^{1}/_{5}$ to ℥j; alcohol, in a 25- to 50-per-cent. solution. Various powders are also blown into the ear—such as alum, iodoform, bismuth, and salicylic acid; but this method of treatment is not to be commended unless the patient is seen daily and the parts thoroughly cleansed by the surgeon before the applications are renewed. The form of application may be changed now and then with advantage. After the irritation and suppuration have subsided, the hearing may sometimes be improved by the insertion of an artificial drumhead. The latter is only of service where the drumhead is partly or wholly destroyed, and where there is such loss of hearing that common conversation cannot be heard. It must be used carefully and removed at once if it causes irritation. The "dry" treatment is sometimes followed with success in chronic suppuration where the moist treatment (douching) has failed. It consists in cleansing the ear daily with probe and cotton, and then making the usual applications, as after douching.

Myringoplasty.—Skin-grafting has been successfully employed for forming a cicatricial drumhead in cases of

chronic suppuration of the middle ear. The method pursued has been to transplant a piece of skin from the patient's forehead, either directly upon the exposed surface of the tympanic cavity or upon the remains of the drumhead the edges of which have been previously freshened. A simple protective dressing, as of borated cotton or gauze, is used. The operation is not likely to succeed unless all purulent discharge has ceased. Myringoplasty was performed upon two cases by Ely (New York) in June, 1878. The first cases published were those of von Berthold, operated upon in August, 1878, and reported in the *Monatsschrift für Ohrenheilkunde* for November, 1878, and Ely (New York) at about the same time. Skin-grafting is frequently employed after the Stacke operation to help line the enlarged external auditory canal. (See description under "Radical Operation of Stacke.")

THE CONSEQUENCES OF CHRONIC SUPPURATION.

POLYPI usually consist of loose connective tissue, cells, and blood-vessels, and are analogous to the well-known exuberant granulations. They generally spring from the tympanic cavity, but sometimes from the auditory canal. The most common cause is a long-continued suppuration of the middle ear. The best method of removing aural polypi is by Wilde's polypus snare or by scissors or curette. Forceps are more dangerous, especially in unskillful hands. The manipulations are performed through a speculum under illumination from the otoscope. Granulations attached by a broad base, which are hard to remove by the snare, may be frequently punctured with needle and then touched with nitric acid or some other strong caustic. The removal of a polypus usually improves the hearing.

MALIGNANT GROWTHS primarily affecting the middle ear are extremely rare. They are to be treated the same as when present in other portions of the body.

VASCULAR NEW GROWTHS are rare also. Buck cites four such cases in his text-book on "Diseases of the Ear," one occurring in his own practice. The treatment consisted in frequent paracentesis of the drum-membrane, and caustic applications, chiefly the nitrate of mercury.

CYSTS are infrequent. Their treatment consists of puncture; if they return, curetting or application of a caustic.

TUBERCULAR NODULES and syphilitic ulcerations are most benefited by treating the general disease.

EXOSTOSES and HYPEROSTOSES, or bony growths, are both congenital and acquired. The congenital ones usually cause no inconvenience and require no treatment. The acquired have an inflammatory origin and most commonly result from chronic suppuration of the middle ear. The local irritation causes first a periostitis and, secondly, an enlargement of bone. Sometimes they occur in connection with a special diathesis, such as the gouty, rheumatic, syphilitic, and tubercular. They may grow so large as to block up the canal and cause fatal retention of pus.

The *treatment* should be directed to the cause. The ear should be kept scrupulously clean, to prevent retention of pus. Iodin may be painted over the tumor. If occlusion occurs, a passage must be opened for the exit of pus by an operation—boring a hole through the tumor with a rat-tail file (Bonnafont), with a drill and dental engine (Mathewson), or they may be chiseled away.

Diseases of the Mastoid.

Although diseases of the mastoid process are very rarely, if ever, independent infections, as the anatomical relations of the cells to the tympanum and to the bony auditory canal plainly show, yet as they have a special importance it may be well to consider them by themselves. Since grip has become epidemic throughout America and Europe acute otitis media has become more frequent and perhaps more severe. The general practitioner is now doubly bound to be alert in the diagnosis and treatment of acute aural inflammation or infection.

Disease of the mastoid includes periostitis, caries, and chronic suppuration. *Mastoid periostitis* often arises in suppuration of the middle ear. It is marked by pain, redness, swelling, and tenderness of the mastoid region. Often there is elevation of the temperature one, two, or more degrees; the pulse is increased in frequency. If not relieved, the inflammation may extend to the brain through some of the connecting foramina, when there may be a sudden drop in the temperature. An incision should be promptly made over the mastoid (Wilde's incision) parallel to the attachment of the auricle and reaching down to the bone. It should not be a mere puncture, but a cut at least $^3/_4$ inch long. In the early stages pus will not be found, but bleeding and relief of tension from the incision will do good. The opening should be maintained by draining with sterilized gauze for a time if necessary. In children, and sometimes in adults, there is a redness and edematous swelling of the mastoid which does not need such a prompt incision, and which may recover without it. It differs from a true periostitis by the absence of the great *tenderness* of the latter affection. Adenitis of

the mastoid is sometimes mistaken for mastoiditis. Careful search for enlarged glands should always prevent this error.

CARIES and SUPPURATION of the mastoid process is an extension of the inflammation last described. The bony partitions between the cells become dissolved and break down into a granular *detritus*. The symptoms do not differ much from those of periostitis except in intensity, and the diagnosis may be difficult. Any persistent, deep-seated pain in the mastoid region is suspicious, especially with a rise of temperature. A fistulous connection with the auditory canal sometimes exists.

Mastoid periostitis, abscess, and caries have occurred without any apparent connection with the tympanum, no disease of the latter having been detected by the most careful examinations.

SCHWARTZE'S OPERATION FOR OPENING THE MASTOID.

In ACUTE MASTOIDITIS, and in many cases of chronic mastoiditis, an operation is necessary. The instruments, dressings, solutions, and so forth, necessary for the operation are: a set of chisels; drills; a mallet; gouges; a scalpel; ear syringe, specula, and head-mirror; two pairs of strong scissors, one straight and one curved; director; retractors; probes; curettes (Volkmann's); periosteum elevator; rongeur forceps; dressing forceps; basins, and so forth. Solutions of bichlorid of mercury (1 to 3000) and carbolic acid (1 to 100); hot water; a great number of sterilized gauze pads for sponging; iodoform gauze (10 per cent.), in strips one inch wide; plain gauze; absorbent cotton; a rubber drain pad, and so forth. The room in which the operation is to be performed should be as nearly aseptically clean as possible, and the surgeon and attendants protected with

aseptic gowns and their hands aseptically clean. The patient is to be prepared for the operation the night before if possible; the side of the head on which the operation is to be performed should be made antiseptically clean, the ear being syringed thoroughly before the operation. The patient must be under a general anesthetic.

The *first step* in the operation is to make an incision back of the ear, beginning above, on a level with the top of the auricle and vertically over the external auditory canal. The incision should be extended downward and backward in a curved direction, about $^1/_2$ inch behind the attachment of the auricle, to the tip of the mastoid, and extending $^1/_2$ inch below the tip. Firm pressure is to be made on the knife so as to go through the soft tissues, periosteum included, down to the bone.

The *second step* in the operation is to separate the periosteum from the bone with a periosteum elevator. Any excessive hemorrhage is stopped, retractors applied, to widen the wound, and the next and

Third step of the operation, chiseling away the outer table of bone from the mastoid antrum and cells, is begun. The spot to begin chiseling first is on a level with the upper margin of the external auditory canal, and about from $^1/_3$ to $^1/_2$ inch back of it, taking the spine of Henle as a landmark. Very thin shavings of bone should be removed with chisel and mallet until the antrum is reached, which lies from $^1/_2$ to $^3/_4$ inch beneath the outer surface. To ascertain if we have reached the antrum a probe bent at the end almost at a right angle should be passed into the opening and directed forward. If it enters the tympanum, we are certain of our position. If the probe will not pass forward the outer opening should be enlarged and then carefully chisel deeper until

the antrum is reached. Sometimes the antrum is sclerosed or absent, when we must chisel directly into the tympanum. Directly on reaching the antrum, the curettes should be used to scrape away soft and broken down bone, being careful not to disturb the anterior part of the antrum, or in only the most careful manner, because the small bones in the tympanum, or the facial nerve, may easily be injured by forcible use of this instrument. Besides, in acute cases, there is but little softened bone, and the chief object is to drain the pus from the antrum and tympanum. The antrum opened and cleaned, the outer table of the mastoid bone down to the tip is removed by means of the chisel and rongeur forceps, and the broken-down cells and all soft bone scraped away with the spoons. When going upward and backward from the antrum toward the sigmoid sinus and where the dura mater lies close, the chiseling should be often interrupted and the probe used so as not carelessly to injure this structure. At this stage of the operation, after all the pus and broken-down cells have been removed from the mastoid antrum and tip, if the under plate of bone appears hard and healthy, most operators are content to stop and dress the wound. Not so with some, however. Buck says the only safe course to pursue in acute suppurative inflammation of the mastoid pneumatic cells is "*to expose to view* (by chiseling away part of this under plate) *a small area not only of the sigmoid sinus, but also of that part of the dura mater which lies in the vicinity of the posterior end of the antrum.*" Of course, any surgeon would remove such portions of bone if they were soft or carious, but we seriously doubt the wisdom of such a procedure where the bone is perfectly sound. It is better, we believe, to dress the wound, and if symptoms

of pus formation arise do a secondary operation after one, two, three, or four days, as indications seem to arise—*i.e.*, sudden rise of temperature.

The *fourth step* of the operation consists in syringing the external auditory canal and wound with sterilized water, and packing the wound firmly with iodoform gauze (10 per cent.), and the external auditory canal lightly with the same material. Over this place plain sterilized gauze and cotton and a firm bandage. The outer dressings may be removed at the end of from twenty-four to forty-eight hours if wet with discharge, but the inner packing should remain undisturbed for from five to eight days, unless there are unfavorable symptoms, as marked rise of temperature. When once removed, the wound should be dressed every second or every third day. It requires from three to eight weeks to complete the cure. If the upper part of the wound is sutured, as is often done, especially where the incision has been carried far forward above the ear, the healing is accelerated. Where, in the course of healing, granulations are excessive and flabby, they should be cut away and cauterized. Some authorities (Roosa) open the mastoid with drills instead of chisels, and only resort to the chisel in case a large area of necrosed or carious bone is found. This method has the advantage of removing only the diseased portion and of lessening the size of the scar. Theoretically it is better because it avoids the very considerable concussion caused by the chisel. For the opening into the antrum, or for removing the outer table a trephine is often used.

Caries and necrosis of the temporal bone may occur from chronic suppuration of the middle ear, and maintain the discharge of pus in spite of all efforts to stop it.

This spot of diseased bone may be very minute or quite extensive. The use of a probe for diagnosis must be very cautious. From the relations of the tympanic cavity, caries of its walls is very dangerous. In some cases the diseased bone is thrown off and the parts heal. Nearly the whole of the petrous bone has been exfoliated in this manner. Fatal hemorrhage has occurred from caries of the walls of the carotid canal, lateral sinus, and jugular vein.

CEREBRAL AND CEREBELLAR ABSCESS.

Suppuration of the middle ear is the most common single cause of cerebral abscess, especially where there is not a free exit for pus. The symptoms of extension to the brain are sometimes insidious. Meningitis may be ushered in with a chill or convulsion, nausea, and vomiting. Or there may be increased pain, followed quickly by paralysis, coma, and death. Or death may occur suddenly without being preceded by brain symptoms. Examination of the eyes is very important in such cases; often "choked" disc is present (Kipp), or one or more of the ocular muscles may be paralyzed. Nystagmus also is sometimes a symptom. If we have good reason to believe that a cerebral abscess exists, the skull should be trephined; part of the outer table removed, usually in the fossa; and the brain explored with a director. If pus is found, the abscess should be opened; gently irrigated with a bichlorid solution, 1 to 10,000; the opening lightly packed with gauze, and dressings applied. It may be necessary to remove the dressing in from twenty-four to forty-eight hours if there is much discharge in them, and the abscess irrigated and redressed. If there is but little discharge, the dressings are less frequent, according to the temperature, the restless-

ness of the patient, and so forth. It requires weeks for a complete cure. If the case terminates fatally, it usually is the result of hemorrhage or extension of the abscess into the ventricles, or from meningitis. The prognosis in cerebral or cerebellar abscess is very grave.

For operative procedures in venous thrombosis of the sigmoid sinus and jugular veins, we would refer the reader to the larger text-books.

PYEMIA, OR METASTATIC ABSCESSES, may occur from aural disease by entrance of pus into the circulation through the mastoid veins or lateral sinus. Several such cases have been reported, some of which recovered.

PARALYSIS OF THE SEVENTH NERVE as it passes through the tympanic cavity in the Fallopian canal may result from suppuration and caries of the middle ear. May be temporary, from pressure on the nerve; or permanent, from destruction of it. It is sometimes injured in opening the mastoid and permanent paralysis results.

RADICAL OPERATION OF STACKE.

Stacke's operation is performed most frequently to relieve chronic suppuration of the middle ear which has not yielded to other treatment. If a chronic suppuration is advancing and cannot be kept in an aseptic condition, an operation is often indicated. Since the radical operation is a serious one, it is not to be lightly undertaken. A serious and intelligent effort should be made to heal a chronic suppuration of the tympanum or to keep it aseptic before an operation which destroys the hearing and is not without danger to life is undertaken. It may be said that with the increased facility and safety of operations upon

the temporal bone, a general knowledge of the methods of treating the tympanum without an operation, has not kept pace. There is a tendency in certain quarters to perform unnecessary operations. The good of the patient should, of course, be the first consideration in the mind of the surgeon in deciding about an operation. After years of urging the rather reluctant profession to undertake operations upon the tympanum and the mastoid, the senior author of this little volume has seen a day arrive when operations are sometimes undertaken when they are not required and are harmful. The treatment of acute otitis media, as taught by Wilde, Tröltsch, Hinton, and others is sometimes not understood and practiced as thoroughly as it should be.

The *first step* consists in making the incision through the soft part back of the ear and separating the membranous canal from the external auditory canal. The incision in the Stacke operation is the same as in the ordinary mastoid operation except that it is carried a little farther forward at the upper part. Only the skin and connective tissue down to the muscle is divided until the lower edge of the temporal muscle is reached, when firm pressure is made on the knife and the periosteum divided from this point to the tip of the mastoid, the incision extending about $^1/_2$ inch below the tip as in the ordinary mastoid operation. The skin and attached border of the auricle are now dissected from the underlying tissue. The auricle and skin are then pulled forcibly forward and a second incision at right angles to the first and beginning at the point where the first incision crosses the lower border of the temporal muscle is made through the periosteum and soft tissue, extending forward to the concha, but not cutting the skin. The periosteum included between

the two incisions is elevated from the bone up to the posterior rim of the auditory meatus, exposing to view the spine above and slightly posterior to the meatus, and down to the lower rim of the meatus, with a narrow elevator the skin lining the meatus is now separated from the posterior bony wall down to the drum-membrane, and a narrow knife introduced into the canal and the skin incised behind and above from its attachment to the annulus tympanicus. The entire cutaneous lining is lifted from the canal by means of a bent elevator and held forward by a blunt retractor.

The *second step* is to remove the upper portion of the drum-membrane, the malleus, and incus, if they are still in position, but to leave the stapes untouched. Then with a chisel or gouge the suprameatal triangle is to be chiseled away, beginning at the forward part of it and continuing backward and upward until the roof of the epitympanic space is continuous with that of the canal. On reaching the antrum and at a depth opposite the facial nerve, Stacke introduces a flat metal protector into the antrum to guard against injury to the nerve and stapes. Backward from the facial nerve and upward the bone may be removed more freely; but even here we must guard against injury to the dura mater. At the lower part of the antrum and forward, the chiseling should be done very carefully, lest the facial nerve be injured. All dead bone should be removed, and, when this part of the operation is finished, the antrum, epitympanic space, and external auditory canal are converted into one common cavity. The posterior wall is on a line with the posterior wall of the antrum, and the upper wall of the bony canal slanting upward to the top of the epitympanic space.

The *third step* is to slit open the membranous canal, beginning at the inner extremity above and carrying the incision longitudinally outward to the concha. At the point where this incision reaches the concha make another incision at right angle to it, downward and backward to the floor of the membranous canal. A quadrilateral cutaneous flap is thus secured which may be used to cover the posterior wall of the bony canal, or even a portion of the floor of the antrum when the soft parts are readjusted. (The direction of the incisions in the membranous canal and the shape of the flap have been modified by some of our American *confrères.* Even part of the concha has been dissected away [Dench] to get a better flap, while a flap of skin from the mastoid region with pedicle [Berens, Philips] has been used to help line the bony walls of the canal. And Davis[1] has made use of the "Cargile membrane" in one case with success in lining the bony canal.)

In order to keep the cutaneous flap in contact with the bony walls the cavity is packed firmly with pledgets of sterilized gauze. The upper part of the wound back of the ear is sutured, while the lower part is packed with gauze and kept open for four or five weeks. Some operators, in this country at least, suture the entire wound behind the ear and try to secure union by first intention, treating the ear through the external auditory canal. A large amount of gauze and absorbent cotton over the ear, held in place with a bandage, completes the dressing. The outside dressing may be removed from the second to the fifth day, but the deeper dressings in the canal and wound back of the ear should not be

[1] Case is yet unpublished.

removed until the seventh or eighth day. The dressings, after this, are to be repeated every second or third day (sometimes daily), as the case demands. Stacke never irrigates the wound during or after the operation, but is always careful to treat it antiseptically. The packing in the canal is kept up, as a rule, for four or five weeks, and excessive granulation tissue is cut away or burned away with galvanocautery or lunar caustic. It may require from one to three or four months for a complete cure.

In this country, at the end of ten days, skin grafting on the raw bony surface is often resorted to with marked acceleration in the cure.

CHAPTER IX.

THE INTERNAL EAR.

Diseases of the Acoustic Nerve.

Nervous deafness is an affection of the auditory nerve or labyrinth, or of both. Primary nervous deafness is the rarest of all aural diseases. Secondary disease of the labyrinth, extending from the middle ear, is frequent. Primary disease may result from injury, such as fracture of the petrous bone; from hemorrhage or serous effusion into the labyrinth through diseased blood-vessels; from inflammation of the membranous labyrinth; from concussions of the nerve, as in boiler-shops, cannonading, etc.; from large doses of quinin, acting by congesting the nerve; from meningitis and cerebro-spinal meningitis, by direct extension of inflammation; from syphilis, perhaps by periostitis and gummata of labyrinth; from fever and the exanthemata; from aneurism of the basilar artery, cerebral tumors, and so forth.

Symptoms.—1. Patients hear better in a quiet place. 2. Noise is often distressing. 3. The tuning fork C^2 is heard better through the air than through the bones. 4. Absolute deafness. The symptom of absolute deafness is pathognomonic, for there cannot be absolute deafness without disease of the acoustic nerve; but very fair hearing, better than in many cases of chronic nonsuppurative inflammation of the tympanum, may exist with disease of the labyrinth. Chronic affections of the nerve are not uncom-

mon, and are often mistaken for chronic catarrh of the middle ear. He who learns to rely upon the tuning-fork will not often make a mistake in the diagnosis. In case of deafness disease invades the nerve in its trunk or expansion. Staggering gait or loss of equilibrium is also a symptom of disease of the cochlea. Many cases in which the latter symptom was marked have been wrongly classified as *Ménière's disease,* after Dr. P. Ménière, of Paris, who recorded several such cases. The only autopsy he made showed the disease confined to the *semicircular canals,* but the case was not a fair type of the others. Such symptoms as *partial* deafness, tinnitus, vertigo, nausea, and vomiting occur also in affections of the middle ear, but nausea and vomiting are rare unless the labyrinth is involved. There are no appearances of the membrana tympani that give evidence of disease of the internal ear. Disease of the cochlea produces deafness for certain tones. This symptom, however, as well as "double hearing" (hearing last notes repeated or echoed) may be secondary to disease of the middle ear causing pressure on the labyrinth.

Treatment.—Each case must be treated according to its symptoms. In acute inflammatory disease, cold applications to the head, leeches, counterirritation, and avoidance of quinin would be indicated. Effusions due to syphilis, except in the first stages, are less amenable to treatment than any other secondary venereal disease, but even they sometimes yield to a thorough antiseptic treatment. Some cases of syphilitic affections of the labyrinth yield to a thorough mixed treatment, and this should always be tried. Chronic affections of the labyrinth are hopeless thus far. Electricity and strychnin have accomplished nothing. Hypodermic in-

jections of pilocarpin, 2-per-cent. solution, beginning with 1 minim and increasing until toxic symptoms appear, are sometimes efficacious.

Deaf-mutism.

This is not a primary affection, but merely a condition secondary to disease or congenital defect of the auditory apparatus. The reason that deaf persons become mutes is that the affection of the ear is present at birth, or so shortly after that its victim is unable to hear and imitate speech. Deaf-mutes thus fall into two classes: (1) the congenital and (2) the acquired. Probably the latter class is fully as large as the former. It does not require absolute deafness in a young child to produce deaf-mutism. A chronic aural catarrh that would only inconvenience an adult may make an infant so stupid that it will soon cease to attempt to imitate speech. Chronic suppurations should be carefully and thoroughly treated in deaf-mutes as in those who hear speech.

Ear-cough, Ear-sneezing, and Ear-vomiting.

Coughing, sneezing, and vomiting from irritations about the external auditory canal have been observed for centuries. Impacted wax or foreign bodies in the canal have been common causes. The phenomena are probably due to irritation of the branch (Arnold's nerve) of the pneumogastric nerve, distributed to the walls of the external auditory canal. The text-books do not agree as to the existence of this branch in the canal, except as an anomaly. As good authorities as Sappey and Gruber describe it. Some authors ascribe ear-cough, etc., to irritation of the auriculo-temporal branch of

the fifth nerve, and say that the communication with the pneumogastric occurs in the brain.

Cophosis (Gr. κωφος, deaf) is a term sometimes used for deafness.

Hyperacusis (Gr. ὑπέρ, beyond, and ακουξ, hearing) is that condition in which the ear is hypersensitive to sound.

Diplacusis (Gr. διπλόος, double, and ακουξ, hearing), *paracusis duplicata,* signifies double hearing. There seems to be some confusion in the text-books in the use of this term. In certain cases of aural disease some sounds are heard naturally in one ear, but are heard one or more tones higher or lower in the other ear; that is, two distinct sounds are heard simultaneously—one, true; the other false. This is double hearing in the strictest sense of the term. This condition has been called *diplacusis binauricularis.* The condition which is much more common, and which is frequently described as double hearing, is that in which the last notes are heard repeated or echoed. Thus, the sounds are heard correctly until just at the close, when there is an echolike repetition of higher pitch in the affected ear. Sometimes the same condition prevails in both ears, and all notes are heard falsely. These peculiar alternations in perception usually affect only the higher notes of the scale. Double hearing is most frequently complained of by people having a musical education, and it is more annoying to such persons than to others.

Presbykousis (πρέσβυς, an old man; ακουω, I hear). —It is claimed that the ears of all persons over 50 years of age undergo senile changes, which cause impairment of hearing, especially in noisy places or when several persons are conversing. The chief symptoms of this condition are worse

hearing in a noise and greatly diminished bone conduction. The pathology of it is thought to be shriveling of the aural tissues and atrophy of the acoustic nerve (Roosa, Orne Green).

VERTIGO.—Vertigo is a symptom that is too frequently ascribed to disease of the labyrinth. It does not occur in aural disease unless the vestibule or semicircular canals are pressed upon, either by a primary exudation in the labyrinth or one from the tympanum, but it is quite a frequent symptom of chronic catarrh and suppurative disease of the tympanum, when a pressure is made upon the fenestra ovalis by pus, mucus, or thickened tissue.

OTALGIA, or *pain in the ear* without inflammatory symptoms, is very rare as a primary affection. It may occasionally result from malaria, syphilis, carious teeth, and so forth. It is often observed in connection with ordinary facial neuralgia. Menthol and glycerin plugs and menthol and Cologne water applications are often successful in subduing the pain. Whenever the otalgia results from constitutional causes these must, of course, be attacked.

INDEX.

Abadie, 131, 161.
Abduction, 57, 174.
Abscess of brain, 276.
  of auricle, 248.
  of cornea, 116.
  of lacrymal sac, 183.
  of orbit, 93.
Absolute hypermetropia, 190.
Accommodation, 2, 186.
  changes in, 13.
  mechanism of, 13.
  paralysis of, 194.
  range of, 45.
  region of, 47.
  spasm of, 195.
Accommodative movements, 24, 186, 194.
Achromatic vision, 198.
Acute catarrh, middle ear, 256.
  suppuration, middle ear, 265.
Acuteness of vision, 44.
Adduction, 57, 174.
Advancement of muscle, 82.
Aërial conduction, 231.
Agnew, 84, 111.
Aids to hearing, 242.
Akouphone, 243.
Akousticon, 243.
Aktol, 71.
Albinos, 16, 19.
Albuminuric retinitis, 141.
Alcohol, amblyopia from, 157.
Alum stick, 72.
Amaurosis, 157.
Amblyopia, 157.
  anemic, 157.
  exanopsia, 157.
  potatorum, 157.
  toxic, 157.
Ametropia, 186.
Ampullæ, 217.
Anatomy of the ear, 199.
    auditory nerve, 226.
    auricle, 200.
    cavity of tympanum, 207.
    cochlea, 215, 217.
    external auditory canal, 203.
      ear, 200.
    internal ear, 215.
      auditory canal, 228.
    mastoid cells, 212.
    membrana tympani, 204.
Anatomy of the ear (*continued*).
    membranous labyrinth, 220.
    middle ear, 204.
    semicircular canals, 215, 217.
    terminal auditory apparatus, 224.
    vestibule, 215.
  eye, 1.
    aqueous humor, 24.
    arteries, 27.
    blood-vessels, 27.
    eyeball, 2, 6.
    eyebrows, 31.
    eyelids, 32.
    choroid, 11.
    ciliary body, 12.
      muscle, 12.
      processes, 14.
    conjunctiva, 33.
    cornea, 19.
    crystalline lens, 21.
    iris, 15.
    lacrymal apparatus, 36.
    lymphatics, 29.
    muscles, 24.
    nerves, 30.
    optic nerves, 4.
    orbits, 2.
    retina, 17.
    sclerotic, 7.
    uveal tract, 7.
    veins, 29.
    vitreous humor, 23.
Anemia, amblyopia from, 157.
Aneurism of orbit, 95.
Angle of iris, 16.
Angulus vestibularis, 223.
Anisometropia, 194.
Ankyloblepharon, 109.
Annular circle muscle of Müller, 13.
Annulus tympanicus, 203.
Anomalies, refraction, and accommodation, 186.
Anterior chamber, 24, 154.
    affections of, 154.
  commissura arcuata, 4.
  elastic lamina, 9.
  fold, 205.
  hemisphere, 7.
  pole, 6.
  pouch, 205.
  vascular zone, 9.
Antihelix, 201.

Antimetropia, 194.
Antiseptics, 90.
Antitragus, 201.
Antrum mastoideum, 212.
Anvil, 209, 210.
Aphakia, 194.
Apparent myopia, 195.
Appendages of the eye, 31.
Aquæductus cochleæ, 220.
vestibuli, 216, 219, 231.
Aqueous humor, 24.
Aquocapsulitis, 128.
Arcus senilis, 38.
Argentamin, 71.
Argyll Robertson, 164.
Argyrol, 71.
Arlt's operation, 87, 178.
Arterial pulse on disc, 61.
Arteries of eye, 27.
of the lids, 35.
Arthritic ophthalmia, 158.
Artificial drum, 268.
eyes, 88, 89, 167.
Aseptic precautions, 64.
Aspergillus, 253.
Associated movements, 27.
Asthenopia, 173, 187.
Astigmatism, 186, 191.
compound, 192.
irregular, 192.
mixed, 192.
simple, 192.
Astringents, 71.
Atrophy of optic nerve, 155.
Atropin, 67.
Attollens aurem, 201.
Attrahens aurem, 201.
Audiphone, 243.
Audition, 199.
Auditory cells, 225.
nerve, 226.
rods, 224.
teeth, 223.
Aural douche, 237.
speculum, 232.
Auricle, 200.
diseases of, 245.
muscles of, 201.
Axis band of hammer, 209.
Axis of rotation, 25.

Bandages, 65, 66.
Bannister, 57.
Basedow's disease, 96.
Base line, 25.
Berens, 280.
Berthold, 269.
Binocular vision, 58.
Blennorrhea, 100.
Blepharitis, 175.
Blepharospasm, 180.
Blindness, simulated, 196.
Blind spot, normal, 51.
Blisters, 238.
Blood-vessels of eye, 27.
Boll, 19.
Bone-conduction, 231.
Bonnafont's operation, 270.
Bonnet's capsule, 4.
Bowman's bougies, 235.
membrane, 9, 13.
operation, 84.
probes, 84.
signs, 44.
trephining of cornea, 75.
Brachymetropia, 190.
Buck, 240, 270.
Bulbus oculi, 6.
Bull, 162.
Buller, 66.
Buphthalmos, 125.
Burnett, 232.
Burns of eye, 97, 112, 181.

Calabar bean, use of, 69.
Canaliculi, 32, 37.
Canal, hyaloid, 23.
of Cloquet, 23.
of Huguier, 208.
of Petit, 23.
of Schlemm, 8.
Canalis centralis modioli, 218.
communis, 217.
ganglionaris, 218.
réuniens, 222.
spiralis modioli, 218.
Canthal ligament, 32.
Canthi, 32.
Canthoplasty, 85.
Canthotomy, 86.
Capsule of eye, 4.
Carcinoma of auditory canal, 254.
Caries of mastoid, 272.
of temporal bone, 275.
Caruncula lacrymalis, 36.
Cataract, 145.
anterior capsular, 118, 147.
black, 148.
capsular, 147.
cortical, 146.
glaucomatous, 160.
hard, 146.
lamellar, 147.
Morgagnian, 146.
nuclear, 146.
operations, 76.
polar, 147.
pyramidal, 147.
secondary, 150.
senile, 147.
soft, 146.
traumatic, 146.
zonular, 147.
Catarrh, acute, of middle ear, 256.

Catarrh, acute, of middle ear *continued*).
chronic, of middle ear, 259.
subacute, of middle ear, 258.
Caustics, 71.
Center of motion, 24.
Central artery of retina, 6.
Cerebral abscess, 276.
Cerumen, 204.
inspissated, 249.
Chalazion, 176.
Chemosis, 99.
Cheselden, 75.
Chief meridians, 191.
Choked disc, 155.
Chondritis, 245, 247.
Chorda tympani nerve, 212.
Choroiditis, 133.
disseminated, 134.
exudative, 134.
serous, 135.
suppurative, 134.
Choroid, the, 11.
atrophy of, 137.
bony deposit in, 137.
coloboma of, 137.
diseases of, 133.
hemorrhages of, 133.
rupture of, 133.
tubercles of, 133.
tumors of, 137.
Chromidrosis, 182.
Chronic catarrh of middle ear, 259.
Chronic suppuration, middle ear, 266.
Cilia, 34.
Ciliary arteries, 9, 28.
body, 12, 138, 142.
congestion, 42.
ganglion, 31.
irritation, 42.
muscle, 12.
spasm of, 195.
nerves, 9.
neuralgia, 128.
processes, 14.
region, 42.
veins, 9.
Circulus arteriosus major, 14.
iridis, 16.
minor iridis, 16.
Cloquet's canal, 23.
Cocain, 42, 69, 72.
Cochlea, 215, 217.
Cochlear nerve, 227.
Cold applications, 66.
Cold douche, 67.
Collargol, 71.
Collyria, 72.
Coloboma, 132.
of choroid, 137.
of iris, 132.
of lids, 181.
Color-blindness, 198.
Color of eyes, 15.
Color-perception, 52.
Compress bandage, 65.
Concha, 201.
Condylomata, 254.
Conical cornea, 124.
lens, 151.
Conjunctiva, 33.
injuries and diseases, 96.
Conjunctivitis, 98.
catarrhal, 98.
croupous, 103.
diphtheritic, 102.
gonorrheal, 101.
granular, 104.
membranous, 102.
phlyctenular, 106.
purulent, 100.
Conradi's method, 76.
Convergent squint, 167.
Cophosis, 285.
Copper sulphate, 72.
Corectopia, 133.
Coredialysis, 127.
Corelysis, 76.
Cornea, 9.
abscess of, 116.
anatomy of, 9.
anesthesia of, 119.
burn of, 112.
conical, 124.
diseases of, 111.
fistula of, 125.
foreign bodies in, 110.
hernia of, 117.
herpes of, 111.
inflammation of, 112.
injuries of, 110, 112.
opacities of, 120.
staphyloma of, 122.
tattooing of, 122.
trephining of, 124.
ulcers of, 117.
wounds, 112.
Corpuscles of von Tröltsch, 205.
Corpus vitreum, 23.
Corrugator supercilii, 31.
Corti's membrane, 224.
pillars, 224.
teeth, 224.
Cotton holder, 238.
Couching, 77.
Crista acustica, 221.
vestibuli, 215.
Critchett's operation, 123.
Croupous conjunctivitis, 103.
Crystalline lens, 21, 145.
absence of, 194.
capsule, 21.
conical, 151.
cortex, 22.
diseases of, 145.

Crystalline lens (*continued*).
  dislocation of, 150.
  layers, 22.
  nucleus, 22.
  poles, 21.
  seams, 22.
Cyclitis, 128, 138.
Cylindrical glasses, 48.
Cysticerci, 154.
Cysts, auditory canal, 254.
  iris, 132.
  middle ear, 270.

Dacryo-adenitis, 184.
Dacryocystitis, 183.
Dacryops, 184.
Daltonism, 198.
Daviel, 77.
Davis, 82, 194, 280.
Deaf-mutism, 284.
Decussation of optic nerves, 5.
Deformities of lids, 178.
Delstanche, 265.
Dench, 280.
Dennert, 232.
Dennett, 63.
Derby, H., 160.
Dermoid tumors, 109.
Descemetitis, 128.
Descemet's membrane, 9.
Detachment of the retina, 143.
De Zeng, 63.
Diagnosis of aural disease, 229.
Dichromatic vision, 198.
Diffuse inflammation of the external auditory canal, 250.
Dioptric, 48.
Diphtheritic conjunctivitis, 102.
Diplacusis, 285.
Diplopia, 62, 170.
Discission, 76.
Diseases of the eye, 92.
Distance, ideas of, 2.
Distichiasis, 178.
Divergent squint, 167.
Double hearing, 283, 285.
Double vision, 53.
Douche, cold, 67.
Douglass, 262.
Downward squint, 168.
Drumhead, 204.
Drum of ear, 207.
Duboisin, 69.
Ductus cochlearis, 219, 222.
Dural sheath, 5.

Ear, anatomy of, 199.
  cough, 284.
  crystal, 221.
  diseases of, 245.
  examination of, 229.
  external, 200.
Ear, anatomy of (*continued*).
  internal, 215.
  irrigation, 237.
  middle, 204.
  muscles of, 201, 202.
    antitragicus, 202.
    dilator of concha, 202.
    helicus major, 202.
      minor, 202.
    obliquus auriculæ, 202.
    tensor tympani, 210.
    tragicus, 202.
    transversus auriculæ, 202.
    stapedius, 211.
  sand, 221.
  sneezing, 284.
  surgery of, 239.
  syringing, 237.
  therapeutics of, 237.
  trumpets, 242.
  vomiting, 284.
Earache, 256.
Earwax, 204.
Ecchymosis of conjunctiva, 97.
  of lids, 181.
Ectopia lentis, 150.
Ectropion, 87, 178.
Eczema, 245, 252.
Ely, 269.
Embolism of central artery of retina, 144.
Emerson's perimeter, 51.
Eminentia stapedii, 208.
Emmetropia, 186.
Engorged papilla, 155.
Entropion, 172.
  operation for, 86.
Enucleation of eye, 88, 164.
Ephidrosis, 182.
Epicanthus, 181.
Epilation, 178.
Epilepsy of retina, 145.
Epiphora, 182.
Episcleritis, 126.
Equatorial plane, 7.
Equator of eye, 7.
Equilateral hemiopia, 51.
Erysipelas, 245.
Erythema, 246.
Eserin, 69.
Eucain, 73.
Euphthalmin, 69.
Eustachian bougies, 235.
  catheter, 233.
  tube, 213.
Eustachius, 213.
Eversion of upper lid, 40.
Excision of the ossicles, 242.
Exophthalmic goiter, 96.
Exophthalmos, 92.
Exostoses, 254, 270.
External auditory canal, 203.

External auditory canal (*continued*).
diseases of, 248.
examination of, 232.
Extraction of lens capsule. 80.
of secondary cataract, 80.
Eye, anatomy of, 1.
diseases of, 92,
examination of, 40.
senile changes in, 38.
surgery of, 74.
therapeutics of, 64.
Eyeball, the, 6.
Eyebrows, 31.
Eyelashes, 34.
Eyelids, 32.
injuries and diseases of, 175.
Eye-shades, 65.

Facultative convergence, 174.
divergence, 174.
hypermetropia, 190.
Fallopian canal, 208.
Far point, 45.
sight, 193.
Fenestra ovalis, 208.
rotunda, 208.
Field of vision, 50.
Fistula of cornea, 125.
of lacrymal sac, 184.
Fixation, central, 52.
eccentric, 52.
Flap extraction of cataract, 77.
Flashes of light in eye, 197.
Floor cells, 226.
Foramen ovalis, 215.
Fontana's spaces, 29.
Foreign bodies, 93, 110, 127, 151, 248, 249.
Fornix conjunctivæ, 33.
Fossa, hyaloid, 21.
navicularis, 201.
patellaris, 21.
triangularis, 201.
Fovea centralis, 19, 61.
trochlearis, 3.
Frostbite, 246.
Fundus of eye, 7.
Fungi, 252.
Furuncles, 251.

Galezowski, 80.
Ganglion spiralis, 227.
Gargling, Tröltsch's method, 263.
Gillet de Grandmont's operation, 130.
Glaserian fissure, 208.
Glasses, 56.
Glaucoma, 158.
absolutum, 160.
acute inflammatory, 159.
chronic, 160.
fulminans, 160.
secondary, 160.
Glioma, 145.
Graefe's extraction, 78, 79.
knife, 79, 241.
test, 57.
Granular lids, 104.
Graves's disease, 96.
Green, 52, 87, 286.
Gruber's method, 236, 284.
Gruening, 158, 180.

Haab magnet, 151.
Habenula tecta, 223.
Hair-cells, 226.
Haller, 9.
Halo, 54.
Hammer, 209.
Hamulus, 219.
Hardened wax, 249.
Hearing distance, 229.
double, 285.
mechanism of, 198.
tests of, 229.
trumpets, 242.
Helicotrema, 219.
Helix, 201.
Helmholtz, 13, 47, 59, 203, 209.
Hemeralopia, 140.
Hemiopia, 51.
Henle's spine, 203, 224, 273.
Hermetical bandage, 65.
Herpes, aural, 246.
ophthalmic, 111.
Highmore, 262.
Hinton, 278.
Hippus, 132.
Hoffman, 233.
Holmgren's test, 52.
Holocain, 73.
Holt's method, 236.
Hordeolum, 176.
Horner, 35.
Hot applications, 67.
Hotz, 87.
Huguier, 208.
Humors of eye, 7.
Hutchinson, 158.
Hyalitis, 153.
Hyaloid artery, persistent, 154.
body, 23.
canal, 23.
diseases of, 153.
fossa, 23.
membrane, 23.
Hydrophthalmia, 125.
Hydrotympanum, 258.
Hypemia, 154.
Hyperacusis, 285.
Hypermetropia, 186, 189.
Hyperostoses, 254, 270.
Hypometropia, 186, 189.
Hypopyon, 116, 154.

Ice coil, 239.
Incisuræ Santorini, 203.
Incus, 209, 210.
Infinite vision, 46.
Inflation of middle ear, 233.
Infra-orbital groove, 3.
Infundibulum, 218.
Inspissated cerumen, 249.
Insufficiency of internal recti, 173.
Intercerebral fibers, 5.
Interference phenomena, 16.
Internal auditory canal, 228.
Internal ear, 215.
diseases of, 282.
recti, tests of, 55.
weakness of, 174.
Interretinal fibers, 5.
Intervaginal space, 5.
Intra-ocular tension, 43.
Intumescentia ganglioniformis Scarpæ, 227.
Iridectomy, 75.
preliminary, 79.
Iridenkleisis, 84.
Irideremia, 132.
Iridochoroiditis, 129.
Iridocyclitis, 128.
Iridodialysis, 127.
Iridodonesis, 132.
Iridotomy, 75.
Iris, 15, 127.
absence of, 132.
coloboma of, 132.
cysts of, 132.
diseases of, 127.
foreign bodies, 127.
injuries of, 127.
malignant disease of, 132.
movements of, 16.
prolapse of, 81, 127.
tremulous, 132.
Iritic angle, 16.
Iritis, 127.
serous, 128.
syphilitic, 128, 130.
tubercular, 130.
Iritomy, 75.
Irritants, 71.
Iter chordæ anterius, 208.
posterius, 207.
Itrol, 71.

Jacobson's method, 80.
Jaesche-Arlt operation, 87.
Javal, 47, 191.
Jequirity, 73.
Jonnesco, 162.

Keratitis, 112.
diffusa, 115.
interstitial, 115.
parenchymatous, 115.
Keratitis (*continued*).
phlyctenular, 114.
suppurative, 116.
vasculosa, 113.
Keratocele, 117.
Keratoconus, 124.
Keratoglobus, 125.
Kerato-iritis, 129.
Keratonyxis, 76.
Kipp, 276.
Knapp, 80, 158, 232.
Koch, 103.
Koller, 42, 72.
Kühne, 19.

Labarraque's solution, 248.
Labium tympanicum, 222.
vestibulare, 222.
Labyrinth, 215.
disease of, 282.
Lacrymal abscess, 183.
apparatus, 36.
diseases of, 181.
canals, 32, 37.
caruncle, 36.
catarrh, 182.
crests, 3.
fistula, 184.
glands, accessory, 34, 36.
diseases of, 184.
groove, 3.
papillæ, 32.
sac, 37.
abscess, 183, 184.
fistula, 184.
Lacrymation, 96.
Lacus lacrymalis, 32.
Lagophthalmos, 180.
Lamina cribrosa, 5, 7.
elastica, 11.
fusca, 8, 11.
propria, 205.
reticularis, 225.
spiralis membranacea, 219.
ossea, 218, 222.
Lapis divinus, 72.
Latent hypermetropia, 190.
Lead, amblyopia from, 157.
deposits in cornea, 121.
Leeches, 66, 238.
Leiter's coil, 239.
Lens, crystalline, 21.
Lenses, cylindrical, 48.
spherical, 48.
Lenticonus, 151.
Lenticular ganglion, 31.
Leucoma, 120.
adherens, 121.
Levator palpebræ superioris, 35.
veli palati, 214.
Liebreich's extraction, 79.
Ligamentum anterius mallei, 209.

Ligamentum incudis superius, 210.
mallei externum, 209.
superius, 209.
obturatorium stapedium, 210.
pectinatum iridis, 10, 15.
posticum, 209.
spirale, 223.
Light perception, 45.
Light-spot, 206.
Limbus conjunctivæ, 33.
laminæ spiralis, 222.
Lime, injuries from, 97.
Limiting membrane, 11, 12.
Linear extraction, 77.
Liquor Morgagni, 22.
Lister, 90.
Lobe of ear, 201.
Local anesthetics, 72.
bloodletting, 66.
Loring's ophthalmoscope, 63.
Lotions, 72.
Lucae, 232.
Lymphatics of eye, 29.
Lymph-spaces of eye, 29.

Macropsia, 197.
Macula acustica, 221.
cribrosa, 216.
lutea, 20, 61.
Madarosis, 176.
Magnets, use of, 151.
Mahoney, 242.
Malformations of auricle, 247.
Malignant disease of auricle, 247.
middle ear, 270.
Malleus, 209.
fracture of, 256.
Manifest hypermetropia, 190.
Manubrium, 209.
Mariotte's blind-spot, 51.
Mastoid abscess, 272.
antrum, 212.
caries, 272.
cells, 212.
periostitis, 271.
primary disease of, 272.
trephining of, 275.
Mathewson, 270.
Mauthner, 63.
McCoy, 182.
Meatus auditorius externus, 203.
internus, 218, 228.
Meckel's ganglion, 31
Median plane of eye, 25.
Meibomian glands, 33.
Meibomius, 33.
Membrana basilaris, 223.
capsulo-pupillaris, 22.
choriocapillaris, 11, 12.
flaccida, 206.
limitans, 12.
Membrana limitans externa, 17.
interna, 17.
nictitans, 33.
propria, 221.
Ruyschiana, 11.
tectoria, 224.
tympani, 204.
appearance of, 205.
examination of, 232.
secundaria, 208.
diseases of, 254.
vestibularis, 223.
Membranous conjunctivitis, 102.
Membranous labyrinth, 220.
Ménière's disease, 283.
Meridians of eye, 7.
chief, 191.
Meridional plane, 7.
Metamorphopsia, 197.
Metastatic abscesses, 277.
Micropsia, 197.
Middle ear, 204, 254.
exostoses of, 270.
inflammation of, acute catarrhal, 256.
chronic, 259.
proliferous, 264.
subacute, 258.
suppurative, 265.
injuries, 254.
polypi of, 269.
Modiolus, 217.
Mucocele, 184.
Mules operation, 166.
Müller's muscle, 13.
Muscæ volitantes, 153.
Muscles of eye, 24.
diseases of, 167.
annular of Müller, 13.
ciliary, 12.
Horner's, 35.
movements, 27.
orbicularis palpebrarum, 34.
stapedius, 211.
tensor tympani, 210.
testing strength of, 55.
Muscular asthenopia, 173.
mesoropter, 24.
plane, 24.
Mutism, 284.
Mydriasis, 131.
Mydriatics, 67.
Myodesopia, 153.
Myopia, 186, 187.
apparent, 195.
false, 195.
Myopic arc, 188.
crescent, 188.
Myosarcoma of auditory canal, 254.
Myosis, 131.
Myotics, 69.
Myringitis, 255.

Myringoplasty, 268.

Nasal douche, 262.
  duct, 37.
  hemiopia, 51.
Near point, 45.
Nebula, 121.
Necrosis of temporal bone, 275.
Needling, 80.
Nerves of eye, 30.
Nervous deafness, 282.
Neuritis optica, 160.
Neuro-paralytic ophthalmia, 119.
Neuro-retinitis, 140.
Nictitation, 181.
Nitrate of silver, 71.
Nodal point, 7.
Nodules, tubercular, of middle ear, 270.
Noise, hearing better in, 261.
  objective, 261.
Nyctalopia, 139.
Nystagmus, 173.

Objective noises in ear, 261.
Oblique illumination, 42.
Ointments, 71.
One-sided deafness, test for, 232.
Onyx, 116.
Opacities of cornea, 120.
Opaque optic nerve-fibers, 156.
Ophthalmia, arthritic, 158.
  catarrhal, 98.
  diphtheritic, 102.
  Egyptian, 100.
  gonorrheal, 101.
  granular, 104.
  military, 100.
  neonatorum, 101.
  neuro-paralytic, 119.
  phlyctenular, 106.
  purulent, 100.
  sympathetic, 162.
  tarsi, 175.
Ophthalmic artery, 27.
  ganglion, 31.
  herpes, 111.
  nerve, 30.
Ophthalmometer, 47, 191.
Ophthalmoscope, 59, 63.
  direct method of use, 60.
  indirect method of use, 60.
  Loring's, 59, 63.
Optic axis, 6.
  canal, 3.
  chiasm, 5.
  disc, 6.
  foramen, 3.
  nerve, 4, 30, 155.
    atrophy of, 155.
    diseases of, 155.
Optic nerve (*continued*).
    entrance of, 8.
  neuritis, 155.
  papilla, 6, 61.
  tracts, 5.
Optico-ciliary neurotomy, 164.
Ora serrata, 20.
Orbits, 2.
  abscess of, 93.
  aneurism, 95.
  caries, 95.
  cellulitis, 93.
  diseases of, 92.
  emphysema, 93.
  exophthalmic goiter, 93.
  hemorrhage, 93.
  inflammation of Tenon's capsule, 94.
  injuries, 92.
  necrosis, 95.
  periostitis, 94.
  tumors, 96.
Orthoptic treatment, 170.
Ossicles of ear, 209.
    dimensions of, 211.
    excision of, 242.
Otalgia, 286.
Othematoma, 246.
Otic ganglion, 212.
Otitis hæmorrhagica, 258.
  parasitica, 252.
Otoconia, 221.
Otolith, 221.
Otophone, 242.
Otorrhea, 266.
Otoscope, 233.
Oval window, 208.

Palpebræ, 32.
Palpebral fissure, 32.
  folds, 32.
  ligaments, 32.
Panas, 78, 80, 161, 179.
  operation for strabismus, 82.
Pannus, 119.
Panophthalmitis, 134.
Paracentesis corneæ, 74, 161.
  membrana tympani, 239.
Parallax, 159, 192.
Paralysis of muscles of eye, 170.
  of accommodation, 194.
  of orbicularis, 180.
  of seventh nerve, 277.
Parasites in ear, 253.
Pars ciliaris retinæ, 20.
Passavant's method, 76.
Peck, 82.
Perception of colors, 52.
  of light, 45.
Perichondritis, 247.
Perichoroidal space, 11, 29.
Perimeters, 51.

Periodic squint, 169.
Periorbita, 4.
Persistent hyaloid artery, 154.
Petit's canal, 23.
Phakitis, 145.
Phillips, 280.
Phlyctenule, 106.
Phosphenes, 197.
Photophobia, 107.
Photopsia, 197.
Physiological excavation, disc, 61.
Physostigmin, 70.
Pial sheath, 5.
Pilocarpin, 70.
Pinguecula, 109.
Pinna, 200.
Plica semilunaris, 33.
Politzer's method, 233, 234, 235, 241, 263, 265, 266.
  acoumeter, 230.
Polycoria, 133.
Polyopia, 54.
Polypi, 253, 269.
Pooley, 152.
Portio mollis, 226.
Posterior chamber, 24.
  commissura arcuata, 4.
  elastic lamina, 9.
  fold, 205.
  hemisphere, 7.
  pole, 6.
  pouch, 205.
  vascular zone, 8.
Poultices, 238.
Presbykousis, 285.
Presbyopia, 193.
Primary deviation, 168.
  position, 25.
Principal meridians, 191.
Prisms, 54.
Probing nasal duct, 84.
Process of Rau, 211.
Processus cochleariformis, 207.
  Folianus, 211.
Prolapse of iris, 127.
Proliferous inflammation of ear, 264.
Promontory, 208, 217.
Protargol, 71.
Protective bandage, 65.
Protective spectacles, 65.
Prout, 229, 235.
Pterygium, 107.
Ptosis, 171, 179.
Pulsation of membrana tympani, 267.
Punctum lacrymale, 32.
Pupil, 15.
  adhesions of, 43.
  contracted, 131.
  dilated, 131.
  eccentric, 133.
  exclusion of, 128.
  movements of, 1, 43.
Pupil (*continued*).
  multiple, 133.
  occlusion of, 128.
Purple of retina, 19.
Pyemia from aural disease, 277.
Pyramid, 208.
Pyramis vestibuli, 216.

Raehlmann, 124.
Range of accommodation, 45.
Ranney, 174.
Recessus cochlearis, 216.
  ellipticus, 215.
  sphericus, 215, 219.
Reclination of cataract, 77.
Reflex symptoms, 174.
Refraction of eye, 47, 62, 186.
    anomalies of, 186.
Region of accommodation, 47.
Reichert's membrane, 9.
Reissner's, 223.
Retina, 17.
  anesthesia of, 140.
  appearances of, 61.
  detachment of, 143.
  diseases of, 139.
  epilepsy of, 145.
  embolism central artery, 144.
  hyperemia of, 139.
  hyperesthesia of, 139.
  purple of, 19.
  tumors of, 145.
Retinitis, 140.
  albuminurica, 141.
  apoplectica, 141.
  leukemica, 141.
  ophthalmoscopic appearances, 141.
  pigmentosa, 142.
  syphilitic, 141.
Retinoscopy, 195.
Retrahens aurem, 201.
Retrotarsal folds, 33.
Rhodes, 243.
Ring, 81.
Rinné's test, 230.
Riolanus, 239.
Rivinian foramen, 206.
  segment, 203.
Rods and cones, 19.
Rood, 52.
Roof cells, 226.
Roosa, 82, 158, 176, 230, 235, 258, 261, 264, 286.
Round window, 208.
Ruyschiana membrane, 11.

Saccule, 222.
Saemisch's operation, 74.
Safety tube, 215.
Sappey, 284.
Sarcoma of auditory canal, 254.
Savage, 82.

Scala tympani, 219.
  vestibuli, 219.
Scalping, 179.
Schlemm's canal, 8.
Schmidt-Rimpler, 165.
Schwartze's radical operation, 272.
Sclera, 7.
Sclerectasia posterior, 136.
Sclerotic, 7.
  diseases of, 126.
  staphyloma of, 126.
  wounds, 126.
Sclerotico-choroiditis posterior, 136.
Sclerotomy, 161.
Secondary deviation, 168.
  position, 25.
Section of sympathetic nerve for glaucoma, 161.
Segment of Rivinus, 203.
Seh-purpur, 19.
Semicircular canals, 215, 217, 221.
  diseases of, 282.
  membranous, 221.
Semilunar fold, 33.
Senile cataract, 147.
Senile changes in eye, 38.
Septum tubæ, 207, 213.
Serum in tympanum, 258.
Shades for eye, 65.
Shadow test, 195.
Shrapnell's membrane, 206.
Siegle, 260.
Silver nitrate, 72.
Simple extraction of cataract, 77.
Simulated blindness, 196.
Sinus sulciformis, 216.
Snellen's artificial eyes, 89.
  test-types, 44.
Snow-blindness, 157.
Soemmering, 20.
Solidity, ideas of, 2.
Solution, medicated, 239.
Space of Tenon, 29.
Spasm of accommodation, 195.
Sperino's method, 161.
  of ciliary muscle, 195.
Sphenoidal fissure, 3.
Spheno-maxillary fissure, 3.
Spheno-palatine ganglion, 31.
Sphincter pupillæ, 16.
Spina tympanica major, 203.
  minor, 204.
  posterior, 203.
Spindle of cochlea, 217.
Squint (*vide* "Strabismus"), 167.
Stacke operation, 269, 277.
Stapedius muscle, 211.
Stapes, 209, 210.
Staphyloma, 113, 122.
  cicatricial, 122.
  operations, 123.
  posterior, 136.
Stauungspapilla, 155.
Stenopeic apparatus, 121.
Stevens, 174.
Stillicidium lacrymarum, 182.
Stirrup, 209.
Strabismometers, 168.
Strabismus, 167.
  convergent, 169.
  divergent, 169.
  operations, 81.
  paralytic, 170.
  periodic, 169.
Strabotomy, 81.
Streatfield's method, 76.
Stria vascularis, 223.
Stye, 176.
Subacute catarrh of ear, 258.
Subconjunctival tissue, 8.
Subdural space, 5.
Subvaginal space, 5.
Suction of cataract, 77.
Suker, 164.
Sulcus tympanicus, 203.
  spiralis externus, 223.
    internus, 222.
Sulphate of copper, 72.
Supercilia, 31.
Suppuration of ear, 265.
Suppurative keratitis, 118.
Suprachoroidal space, 11, 29.
Suprachoroidea, 11.
Supra-orbital notch, 3.
Supravaginal space, 29.
Surgery of ear, 239.
  of eye, 74.
Sursumduction, 57.
Suspensory ligament, iris, 15.
  lens, 22.
Symblepharon, 109.
Sympathetic inflammation, 163.
  irritation, 163.
  ophthalmia, 162.
Synchysis, 153.
  scintillans, 153.
Syndectomy, 120.
Synechia, 117, 128.
Syringing the ear, 252.

Tannic acid, 71.
Tansley's method, 236.
Tapetum, 15.
Tarsal cartilages, 32.
  cyst, 176.
  ligaments, 32.
Tattooing of cornea, 122.
Tear-passages, diseases of, 182.
Tears, 36.
Temporal hemiopia, 51.
Tendo oculi, 33.
  palpebrarum, 33.
Tenonitis, 94.
Tenon's capsule, 4.

Tenon's space, 11, 29.
Tenotomy, 81.
Tension, intra-ocular, 43.
Tensor choroideæ, 12.
tympani, 210.
Terminal auditory apparatus, 224.
Testing the power of the ocular muscles, 55.
Tests of hearing, 229, 232.
Test-types, 44.
Theobald, 85.
Therapeutics of ear, 237.
of eye, 65.
Third eyelid, 33.
Thomson, 52.
Tinea tarsi, 175.
Tinnitus, 260.
Tobacco amblyopia, 156.
Tonometers, 44.
Toynbee, 261.
Trachoma, 104.
Tractus foraminosus, 227.
Tragus, 201.
Trephining of cornea, 75.
of mastoid, 275, 276.
of sclera, 160.
Trial glasses, 48.
Trichiasis, 178.
Trochlea, 26.
Tröltsch, 261, 263, 278.
Tscherning, 13, 14.
Tumor of auricle, 246.
epithelioma, 247.
erectile, 246.
lupus, 247.
othematoma, 246.
sebaceous, 246.
vascular, 246.
Tunica vaginalis bulbi, 4.
vasculosa, 7, 11.
Tunics of eye, 7.
Tuning-fork, use of, 229.
Tylosis, 176.
Tympanic cavity, 207.
groove, 203.
plexus, 212.
ring, 203.

Umbo, 205.
Unguis, 116.
Upward squint, 167.
Utricle, 220.
Uvea, 15.
Uveal tract, 7, 11.

Valk, 82.
Valsalva's method, 235, 241, 260.
Valsalvian experiment, 235.
Van Fleet's operation, 179.
Vascular growths of ear, 267, 270.
zone, 8, 9.
Vas prominens, 224.
spirale, 223.
Veins of the eye, 29.
Venæ vorticosæ, 8, 12.
Venous pulsation, on disc, 61.
thrombosis of sigmoid sinus, 277.
Vertical meridian, 25.
Vestibular nerve, 227.
Vestibule, 215.
Vision, 1.
acuteness of, 44.
Visual angle, 44.
field, 50.
line, 6.
plane, 25.
purple, 19.
Vitiligoidea, 182.
Vitreous humor, 23, 151.
cysticerci in, 154.
diseases of, 151.
fluidity of, 153.
foreign bodies in, 151.
hemorrhage into, 152.
opacities of, 152.
Voice test, 244.
Volkmann's curettes, 272.
Voluntary hypermetropia, 190.
Von Tröltsch, 205, 233.
Vorticose veins, 8, 12.

Wadsworth, 63.
Waldeyer, 224.
Wallace, 13.
Watch test, 229.
Watery eye, 182.
Webster, 151, 162.
Wecker, 161.
scissors, 76.
Weeks, 80, 103, 162.
Wenzel, 75, 76.
Wilde's incision, 266, 271, 278.
snare, 269.
Williams, 52.
Wilson, 80.

Xanthelasma, 182.
Xanthoma, 182.
Xerophthalmia, 108.

Yellow spot, 20.

Zinn, ligament of, 26.
Zona pectinata, 226.
Zone of Haller, 9.
Zonula ciliaris, 22.
Zinnii, 22.
Zygomatico-facial foramina, 3.
-temporal foramina, 3.